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ABSTRACTS FOR

IAU SYMPOSIUM 160: ASTEROIDS, COMETS, METEORS 1993

Belgirate (Novara), Italy
June 14–18, 1993

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Organized by
Osservatorio Astronomico di Torino
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Preface

This volume contains abstracts accepted for presentation at IAU Symposium 160: Asteroids, Comets, Meteors, 1993 in Belgirate, Italy, June 14–18, 1993. Abstracts are presented in alphabetical order of first authors. No distinctions have been made between invited papers, contributed papers, and poster papers.

The Scientific Organizing Committee was chaired by V. Zappalà. Members of the committee were E. Bowell, A. Brahic, A. Carusi, Z. Ceplecha, M. Coradini, D. Davis, P. Farinella, M. Festou, Cl. Froeschlé, A. Harris, J. Henrard, Y. Kozai, C. I. Lagerkvist, A. C. Levasseur-Regourd, B. Lindblad, D. Lupishko, B. Marsden, A. Milani, J. Rahe, H. Rickman, E. Shoemaker, A. Sokolsky, G. Valsecchi, I. P. Williams, and P. Weissman. The Local Organizing Committee consisted of M. Di Martino (Chair), C. Blanco, C. Casacci, A. Cellino, G. De Sanctis, P. Jones, and A. Manara.

The conference was organized by Osservatorio Astronomico di Torino and the Lunar and Planetary Institute, Houston, and is sponsored by the International Astronomical Union (IAU). We acknowledge the contribution of Regione Piemonte, Provincia di Novara, A.P.T. Lago Maggiore, Consiglio Nazionale delle Ricerche, European Space Agency (ESA), and Alenia Spazio S.p.A. The participation of Banca Popolare di Novara, Camera di Commercio di Novara, and Martini & Rossi IVLAS S.p.A. is acknowledged. We also acknowledge the support of the following: Ambrosi S.p.A., Barbero 1891 S.p.A., Cantine dei Marchesi di Barolo, Azienda Agricola Bianchi, Antichi Vigneti di Cantalupo, Cantine del Castello di Conti Cav. Ermanno, Istituto Geografico de Agostini, Azienda vitivinicola Dessilani, Ferrero Industrie Dolciarie, Fratelli Francoli S.p.A. Distillerie, Cantina Sociale di Gattinara, Consorzio Novarese Gorgonzola, Nestlé Italia S.p.A. Vismara, Raspini S.p.A., and Zoppis & Giromini S.R.L.

Logistics and administrative and publications support for the conference were provided by the staff of the Publications and Program Services Department, Lunar and Planetary Institute. Computer service support for the preparation efforts was provided by the Computer Center, Lunar and Planetary Institute.

CONTENTS

Dependence of Meteor Beginning Heights on Meteoroid Rotation

L.G. Adolfsson & B.Å.S. Gustafson

Department of Astronomy, University of Florida, Gainesville, Florida 32611, U.S.A.

The temperature profile for a meteoroid as it penetrates the Earth's atmosphere is highly dependant on the dimension of the meteoroid. The first approach was taken by Whipple (1950) where he neglected the heat capacity in micrometeorites. The theory was further developed to account for thermal capacity as well as thermal conduction (Levin (1965)). By neglecting thermal radiation from the surface Ceplecha and Padevět (1961) were able to get an analytical solution for a rapidly and randomly rotating sphere. In the same manner, *i.e.* neglecting thermal radiation, Pecina (1991) could account for rotation of the spherical meteoroid to get analytical expressions for the temperature.

We integrate the general heat conduction equation

$$\nabla^2 u = \frac{\delta c}{\lambda} \frac{\partial u}{\partial t}$$
$$\frac{\partial u}{\partial n} = \frac{W}{\lambda}$$

numerically where $u = u(\overline{r}, t)$ is the temperature at the coordinate $\overline{r}$ inside the body, $\frac{\partial}{\partial n}$ is the outward normal derivative, W the heat flux, δ, c andρ are the density, specific heat and thermal conductivity of the meteoroid. In our approach we can quite generally let our heat flux W contain both thermal radiation and thermal capacity. Since we solve the problem for any point in the body we obtain an exact expression for the surface boundary conditions.

Using this method we investigated the dependance of meteor beginning heights on rotation of the meteoroid. The beginning height of a non-rotating sphere can differ by as much as 10 km from the beginning height of a rapidly and randomly rotating sphere, when the meteoroids are large enough to have a temperature gradient built up within the body. In conclusion, the rotational state of a large meteoroid during atmospheric flight can not be ignored in calculating beginning heights.

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Levin, B.Y., The Physical Theory of Meteors and Meteoric Matter in the Solar System, Izdatel'stvo Akad. Nauk SSSR, (1965), [in Russian].

Pecina, P., *Bull. Astron. Chech.*, **42**, 359–376, (1991).

Whipple, F.L., *Proc. Nat. Acad. Sci. Amer.*, **36**, 687–695, (1950).

Meteoroid Material and Beginning Heights Within Meteor Streams

L.G. Adolfsson & B.Å.S. Gustafson

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One of the most reliably determined quantities from stereoscopic meteor observations is the beginning height. The luminosity of a meteor increases abruptly at the onset of ablation where an observable meteor trail soon begins. This usually precedes any fragmentation, which simplifies modeling. The beginning height depends on the meteoroid trajectory, entry geometry and meteoroid morphology. Ceplecha (1968) may have been first to use beginning heights to distinguish classes among photographed meteors (McCrosky and Posen (1961)), which he ascribed to differences in meteoroid densities.

We develop a formalism for modeling beginning heights accounting for heat diffusion with thermal radiation as well as vaporization and cooling due to removal of latent heat. Restricting the study to stream meteors simplifies the problem in that meteoroids within a given stream arrive along parallel trajectories at near equal velocities and may be assumed to be of similar material. Stream meteor data cover a range of zenith distances and meteoroid dimensions which we use to constrain the meteoroid material and morphology.

Ceplecha, Z., *Smithsonian Astrophysical observatory Special Report No. 279* , 54 pages, (1968).
McCrosky, R.E., Posen, A., , *Smithsonian Contributions to Astrophysics*, **4**, 15–84, (1961).

ASTEROID FRAGMENTS IN EARTH-CROSSING ORBITS

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3. Observatoire de la Côte d'Azur, Dept. CERGA, Avenue Copernic, F-06130 Grasse, France

The dynamics of small bodies in the Solar System is ruled also by non-gravitational forces as the Poynting-Robertson effect and the Yarkovsky effect.

The easiest explanation for the Poynting-Robertson drag force is identifyng it with the phenomenon of light aberration. This effect is dissipative and makes the particle spiral inwardly to the Sun. For meter-sized bodies, Poynting-Robertson is very weak to cause any observable effect. Another transverse force, also induced by radiation pressure, is dominant for this size range: the Yarkovsky effect.

The idea behind Yarkovsky effect is that reemission of radiation from a rotating body is higher in the dusk hemisphere than it is in the dawn hemisphere, thus creating a force in the direction opposite to the hotter hemisphere. The Yarkovsky force can be dissipative or antidissipative causing the body to spiral inward or outwardly to the Sun, respectively.

The purpose of this work is that of better understanding the dynamics of meter-sized bodies (for instance asteroid fragments) subject to Yarkovsky effect and in resonance with the main planets. We make the deduction of the Yarkovsky effect solving the time-dependent heat conduction equation. We present some examples with the dissipative and the antidissipative forces.

The dissipative force may confirm that many of meteorites found on the surface of the Earth have their origin in the combined effect of Yarkovsky force and resonances with Jupiter.

With the antidissipative force some good examples of trappings in resonances with Jupiter can be found, because in these cases the orbits are converging and capture is more natural.

Astrometry of Near-Earth Asteroids from Victoria, G.C.L. Aikman, Dominion Astrophysical Observatory, National Research Council Canada, and D.D. Balam and J.B. Tatum, University of Victoria.

In order to expedite accurate orbital determination of Earth-approaching asteroids, initial discoveries must be followed by astrometric tracking over arcs long enough to enable reliable recovery of such objects at later apparitions. Our astrometric program at Victoria combines CCD imaging with 1.8-m and 0.5-m reflectors and photographic imaging with a 0.25-m Schmidt telescope, to allow tracking of newly recognized objects to faint magnitudes, as well as wide-angle recovery of some brighter objects. Some of the more interesting objects monitored in recent months will be discussed.

ON THE FAN-SHAPED COMA AND THE THERMAL HISTORY OF COMET P/GUNN

Hiroki Akisawa[1], Ken Sugawara[2], Mitsunori Tsumura[3] and Jun-ichi Watanabe[4]

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2: Atsugi City Children's Science Centre, 1-1-3 Nakacho, Atsugi City, 243 JAPAN
3: Wakayama City Children's Science Centre, 19 Yoriai-machi, Wakayama City, 640 JAPAN
4: National Astronomical Observatory, Mitaka City, Tokyo, 181 JAPAN

Abstract

We observed about the fan-shaped coma (Figure) and the visual magnitude of comet P/Gunn during from February to September in 1989. We determined the direction of rotation axis from the position angle of the fan-shaped coma by Sekanina(1979)'s method. From the rotation axis, we calculated the thermal history of each latitudes on the nucleus. This calculation indicated that the northern hemisphere of the nucleus was heated before perihelion passage. However, the light curve of visual magnitude of the comet was symmetric to perihelion passage. These conclusions suggested the dust mantle was probably developed on the nucleus of comet P/Gunn.

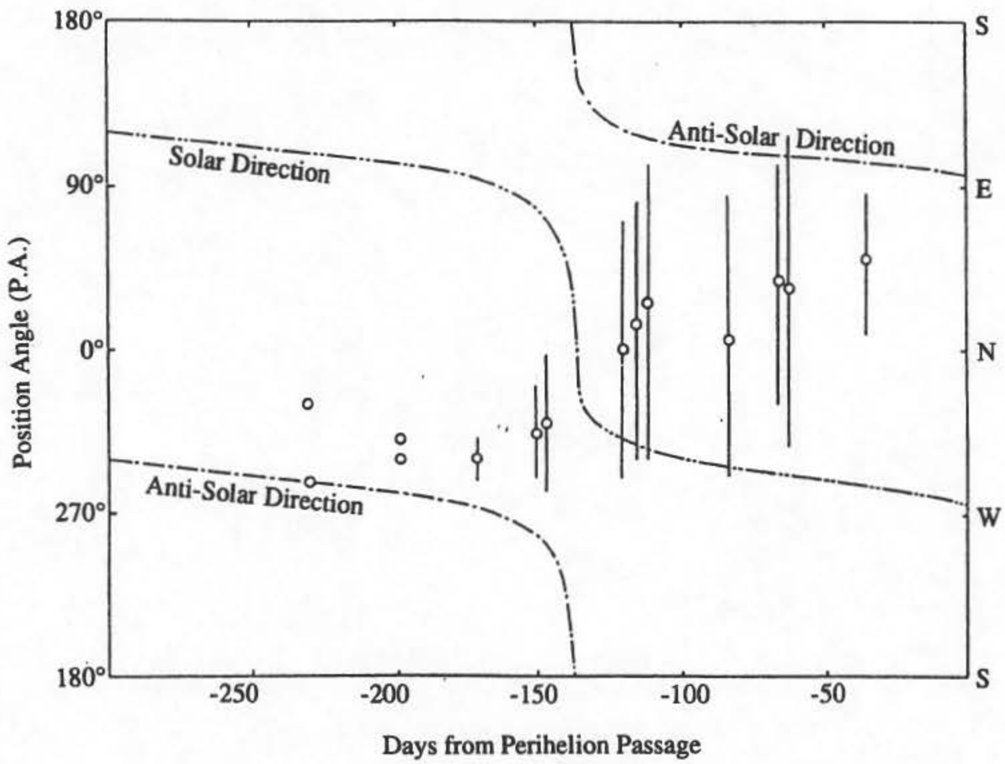

Figure: The position angle (degree from north to east) of fan-shaped coma of comet P/Gunn

Reference

Sekanina, Z. (1979), ICARUS 37, pp. 420-442

E.V.Alfimova
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"The Modeling of Stochastic Orbits of Minor Planets".

The asteroidal belt considered as stochastic dynamical system of many objects. Integration of stochastic equation of the process of evolution of the belt as Markoff's semistationary semiergodic process, in toroidal coordinats, given about 80% of objects in inner part of the belt have stochastic orbits. That is the model of the process have the property of the absence of after-action, than the finding of eigenvalues of state matrix of each object in some appointed time moment give us the possibility of prognosing of more probable trajectories of that objects in thefuture. For example there are results of culculations for two asteroids from NEA's class.

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"Stochasticity of the Process of Formation of the Asteroidal Belt in the Solar System".

In this work the problem of investigation of the process of formation of the asteroidal belt in the Solar system is qualitatively well-founded. This process is stochastic semistationar Marcoff's process, if their objects are stochastic dynamical system. There are basic equations of this process and characteristic energing distribution of known minor planets.

RECENT ACTIVITY OF THE KONKOLY OBSERVATORY IN COMETARY AND ASTEROID RESEARCH

I. Almár, J.Kelemen
Konkoly Observatory, Budapest, Hungary

New European Subnode of the PDS Small Bodies Node in Budapest

NASA has recently established a European Subnode of its Planetary Data System in our Institute. It will provide distribution of NASA's data on small bodies in the Solar System within Europe and will also provide expertise and assistance in archiving the data from selected space missions.

ON LINE CAPABILITIES: Specially selected data files are available through Internet (E-mail or remote login).

CURRENTLY AVAILABLE DATA SETS: Complete IHW CD-ROM set with corresponding manual and other CD-ROM-s. Further data sets will be added soon.

NODE CONTACT INFORMATION: Address: H-1525 Budapest POB 67, Hungary
FAX: 36-1-1569640 E-mail: pdsc astro.rmki.kfki.hu

VEGA TV System Comet Halley imaging experiment

During the last decade the Central Research Institute of Physics (KFKI) Budapest, and the Konkoly Observatory performed an extensive study of Comet Halley using the VEGA TV System experiment:

1/ Near nucleus region, jets: Intensity profiles along the axes of jets within 100 km of the nucleus of Comet Halley were analysed and a sharp deviation from a 1/r dependence toward a less steep gradient was found.

2/ Rotational motion of the nucleus: Using both ground based and spacecraft observations, the VEGA TVS team at the KFKI continued to analyse the rotational motion of the nucleus.

3/ International Halley Watch Archive: Spacecraft and ground based observations were sent to the IHW Archive, namely VEGA-1 and VEGA-2 raw and processed images and photographic observations carried out with the Schmidt telescope of the observatory.

Asteroid observations

Photoelectric photometric observations of selected asteroids were carried out in order to determine their shape, rotational properties and surface irregularities by analysing the light curves.

HIGH RESOLUTION IMAGING OF COMETS AND ASTEROIDS USING BISPECTRAL TECHNIQUES

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Speckle interferometry techniques have proven that very high spatial resolution imaging could be performed from ground-based observatories, thus allowing to reach the diffraction limit of telescopes. Yet, the full success of the technique relies on the high quality of the observing site since the overall S/N ratio varies as the 4th power of the atmospheric seing. The Pic du Midi Observatory is renown for the exceptional quality of its skies during a significant part of the year. A speckle imaging program at the 2-meter Bernard Lyot telescope was consequently designed to apply this method to a wide set of astrophysical problems that could benefit from a resolution of 0.06 arc sec near 6000 Å. A speckle camera has been build and is currently being tested. The first observations are planned for June and July 1993. We briefly present the image restoration methods we have developped and tested on both synthetic and real data. These methods are based on bispectral phase recovery with least square minimization followed by regularized deconvolution. We then describe the potential of the technique for the study of small bodies of the solar system.

DETERMINATION OF SOME METEOR STREAMS CHARACTERISTICS BASED ON THE EARTH'S PATH LENGTH. Gennadij V. Andreev, Astronomical Observatory of Tomsk State University, 634010 Tomsk, Box 1106, Russia.

The length of the Earth's path in meteor streams is one of the most exactly measured values (3–4 orders better than others). This article shows the possibilities of using the Earth's path length for the solution of the following tasks:

- Determination of the size and form of the cross section of the meteor stream's observed parts;
- Estimation of the upper limit of the real dispersion of orbital elements, coordinates of radiants and velocities of meteoroids in the meteor streams;
- Calculation of the upper values of particles' ejection velocities from family bodies by comparison of the measured length of the path depended on dispersions of orbital elements with the theoretical one, which is a function of the ejection velocities;
- Determination of the total mass of streams (lower estimation of mass of the family body) by means of known activity curve of the flux particles and the length of the Earth's path between the lines of equal density of the meteor flux;
- Calculation of the upper estimations of the meteor stream's age.

It was shown that in many cases even the upper estimations of the above-mentioned parameters are less than their observed values obtained with the help of the most exact photographic method. This is not only telling of the poor precision of the observed data but demonstrates that it makes sense to use the estimations obtained with the help of Earth's path length in the statistical problems of meteor astronomy.

1908 TUNGUSKA EVENT: ENERGY, ORBIT, COMPOSITION, ORIGIN. G. V. Andreev, V. V. Goldin, N. V. Vasilyev, Tomsk State University, Box 1106, 634010 Tomsk, Russia.

This paper reviews the Russian published and unpublished data on the Tunguska 1908 explosion.

On June 30 at 00 h:14 m UT a catastrophic collision of a small cosmic body with the Earth took place over Central Siberia in the interriver of Podkamennaya and Nizhnyaya Tunguskas (60.9 grad to N; 101.9 grad to E). The Tunguska cosmic body exploded at an altitude of 5–8 km, with an energy of ~20–50 Mtn TNT. The object responsible had a radius of ~40–100 m. The forest, which is 2150 m^2 in area, was felled radially from the epicenter. A special field program of the Tunguska Expedition was carried out over 15 years to investigate the inner structures of the directions of the fallen trees. The seismic waves were fixed in Jena, Irkutsk, Tashkent, and Tiflis. These fundamental data provide a good opportunity for the reconstruction of the picture of atmospheric disruption and explosion of the Tunguska body.

The coordinates of the visible radiant were determined with help of the eye-witness testimonies catalogue. This apparent geocentric radiant (A = 300–310, H = 12–22 grad) corresponds to the heliocentric orbit of Apollo-type asteroids or "burnt-out" comets.

For determination of the element and isotope composition of the Tunguska object, an area of 15,000 km^2 was covered by the cosmochemical survey. This paper analyzes the more-than-30-year history of the Tunguska Expedition Cosmochemical Program.

Data on the Tunguska geomagnetic effect, on the local remagnetization of soils, on the changes of thermoluminescent properties of rocks, on the atmospheric optical and polarization anomalies, on the biological (including genetic) after-effects are discussed.

This paper reports on the aims and first results of the International Tunguska Expedition and International Research Program.

HYPERBOLIC METEOROID FLUX NEAR EARTH ORBIT. G. V. Andreev[1], B. L. Kashcheyev[2], S. V. Kolomiets[2], [1]Astronomical Observatory of Tomsk University, Tomsk, Russia, [2]Institute for Radioelectronics, Kharkov, Ukraine.

This article deals with the hyperbolic meteors observed in Earth's atmosphere. A very highly sensitive radar method of meteor observation has been developed at the Kharkov Radioelectronic Institute. During a two-year cycle of observations the orbital elements were determined for 100,000 meteors; the number of hyperbolic meteors is 1.1%. This paper analyzes the reality of hyperbolic orbits of observed meteors. Specifically, we have been able to show that 25% of such orbits can turn into elliptic orbits by using more correct celestial mechanics expressions. Nevertheless 5% of the hyperbolic orbits are unexplained by errors of observations and calculations.

The distributions of the orbital elements of observed meteors were compared with the theoretical one in the search for the hyperbolic meteor sources. This report analyzes such possible sources as: cometary decay, collisions in the asteroidal belt, close approaches to the planets, and capture of interstellar dust by the solar system.

COMPARISON OF ORBITAL ELEMENT DISTRIBUTIONS FOR DIFFERENT METEOR CATALOGUES AND POSSIBLE STRUCTURE OF SPORADIC METEOROID COMPLEX

V.V. Andreev.
Engelhardt Astronomical Observatory, Kazan, Russia.

The division of the sporadic meteoroid complex depending on inclination and Tisserand's constant of meteoroid orbit into several groups has been carried out in previous author's papers (Andreev 1988, 1992). As the result of peculiar orbits of particles has been found. The orbits are not similar ones of comets and asteroids.

The conditional orbital element distributions of meteors for fixed values of inclinations have been analysed for five meteor catalogues to determine of dependence of the distributions on inclination and mass, and to carry out more accurate division of meteoroid complex into groups. The catalogues are: catalogue of photographic meteors (McCrosky & Posen 1961), two catalogues of radar meteors obtained at Adelaida, the results of radar meteor observations in Soviet equatorial expedition in Somalia, and in Kharkov.

Andreev V.V. 1988. Second GLOBMET Symposium, Abstracts, 17- 18.
Andreev V.V. 1992. Asteroids, Comets, Meteors - 1991, (Eds. A. Harris and E. Bowell), 5- 8.
McCrosky R.E., Posen A. 1961. Smithson. Contr. Astrophys, 4, No.2, 15- 84.

MASS DISTRIBUTION OF SPORADIC METEOR BODIES

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Engelhardt Astronomical Observatory, Kazan, Russia.

It is well known that the masses m of sporadic meteor bodies are distributed as $P(m) = (s-1)\ m_o^{s-1}\ m^{-s}$, where m_o is the minimal value of mass and s is the mass law exponent. The problem is the variations the value of s over the celestial sphere, with time, and whether it depends on the value of meteoroid mass and on some of elements of meteoroid orbits.

Radar observations carried out in Kazan were used to find out the variations of the mass exponent s over the celestial sphere. Two methods of determination of s were applied: the first one is the calculation of s from the comparison of the sporadic meteor flux densities (Andreev et al, 1992) at several amplitude levels and the second one is the determination of s from amplitude distributions obtained for different areas at the celestial sphere find out similarly to the flux density. Both methods have given similar results - the value of s does not depend on the times of a year but it is the function of the elongation angle ε from the Earth apex only. The approximation is:

$$s(\varepsilon) = 2.025 - 0.21\cos(\varepsilon) + 0.076\left(\sin^3(1.52\varepsilon) - \left|\sin^3(1.52\varepsilon)\right|\right).$$

The minimal value of s = 1.82 corresponds to $\varepsilon = 0°$ and maximal one s = 2.16 is at $\varepsilon = 140°$. Analysis of photographic (McCrosky & Posen, 1961) and television (IAU Meteor Data Center at the Lund Observatory, Sweden) observations of meteors confirms the radar results but variations of s are more strongly pronounced: minimal and maximal values of s are 1.44, 1.22 and 2.52, 2.31 for photographic and TV data respectively. Selections of observation methods have been taken into account.

Andreev V.V., Belkovich O.I., Filimonova T.K., Sidorov V.V. 1992 Determination of Meteor Flux Distribution over the Celestial Sphere. Asteroids, Comets, Meteors - 1991, (eds. A. Harris and E. Bowell), 17- 22.

McCrosky R.E., Posen A. 1961. Orbital Elements of Photographic Meteors. Smithson. Contr. Astrophys, 4, No.2, 15- 84.

SOME PECULIARITIES OF VELOCITY AND RADIANT DISTRIBUTIONS OF SPORADIC METEOROIDS

V. V. Andreev, O. I. Belkovich, S. L. Suleymanova

Engelhardt Astronomical Observatory, Kazan, Russia.

It was found from radar observations (Andreev et al, 1992) that sporadic meteor radiant distributions P (ε,ψ) have a symmetry relative to the plane crossing the Earth's apex, ecliptic pole and antapex. Here ε is the meteor radiant elongation from the Earth's apex, and ψ is the azimuth angle measured between the ecliptic plane and plane crossing through apex, radiant and antapex. The radiant distribution averaged over a year has also the symmetry relative to ecliptic plane. This fact confirms the Opik's suggestion about the uniform distribution of perihelion arguments of meteoroid orbits with given values of a, e, i. Then averaged sporadic meteor radiant distribution over entire celestial sphere can be represented by one quarter of the sphere.

Conditional distributions of meteor velocities u $P^{x}_{\varepsilon,\psi}$ (u) obtained from catalogues of sporadic meteors from photographic and radar observation have been analyzed. It was found that the distributions do not depend on the azimuth angle ψ.

Conditional distributions of meteoroid velocities P_{ε} (u) have been obtained tacking into account of the selectivity of the observation method and the variation of the mass exponent s over the celestial sphere.

Andreev V.V., Belkovich O.I., Filimonova T.K., Sidorov V.V. 1992 Determination of Meteor Flux Distribution over the Celestial Sphere. Asteroids, Comets, Meteors - 1991, (eds. A. Harris and E. Bowell), 17-22.

Opik, E.J. 1951. Proc. R. I. A., 54, Sec. A, No. 12, 165-199.

CCD OBSERVATIONS OF SMALL ASTEROIDS

C. Angeli, M.A. Barucci, M. Chevreton, G. Herpe (Observatoire de Paris, Meudon, France), C. De Sanctis (Istituto Astronomico, Universitá La Sapienza, Rome, Italy) and M. Fulchignoni (Dipartimento di Fisica, III Universitá di Roma, Italy)

We are continuing the long-term observational program started by our group in 1984 to study rotational properties of small asteroids with a diameter less than 50 km. These small asteroids put important constraints on the models of asteroid collisional evolution; the knowledge of their rotational properties help in understanding the formation and the evolution of the Solar System.

Asteroid rotation is the result of the angular momentum added by mutual collisions to the initial angular momentum determined by the formation processes. The knowledge of the actual distribution of the spin rates can help to interpret the evolutionary scenario (collision, fragmentation, etc) of these objects. Most of the current knowledge on asteroid rotational properties is deduced by the analysis of the photoelectric and CCD photometry lightcurves.

Up to now, the rotational periods of about 250 asteroids with $D \leq 50$ km are known; this represents a very poor sample of a population that, even if we limit our analysis to the kilometer size objects, contains several thousand of objects.

In this work we present the results obtained during 19 good nights in the period spanning between july 27 1992 and february 1 1993. The observations of asteroid CCD lightcurves were carried out at Haute-Provence Observatory (France) using the 1.2m telescope, and at Calar Alto Observatory (Spain) using the 1.5m telescope. The result of this work is the determination of the rotational periods of the asteroids 2078 Nanking, 1441 Bolyai, 1520 Imatra, 4455 1988XA, 2241 1979WM, 3139 Shantou, 3725 Valsecchi, 3485 Barucci, 4708 Polydoros, 4015 1979VA, 4140 1976VA, 3986 1985SF2 and 2557 Putnam.

Observations of CH, NH, and NH_2 in Comets P/Hartley 2 (1991 XV) and Shoemaker-Levy ($1991a_1$) using the Hubble Space Telescope

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The study of minor species observed in cometary spectra is important as it may allow constraints to be set on the relative abundances of their progenitors in the cometary nucleus and thus, hopefully, provide information of cosmogonic significance. For example, it would be interesting to obtain meaningful values, or upper limits, for the CH_4/H_2O and NH_3/H_2O ratios, as these may give some insight into the processes and conditions prevailing in the regions where comets were formed. With this aim in mind, we have analysed a series of spectra obtained with the Faint Object Spectrograph (FOS) on the Hubble Space Telescope, showing, among others, the emissions due to the methyladyne radical, CH, some of which may come from methane, and the imidogen, NH, and amine, NH_2, radicals, both of which are probably produced mainly by the photolysis of ammonia. These spectra have the following particularly favorable characteristics : (1) they refer to two comets of different dynamical ages, P/Hartley 2 (1991 XV) and Shoemaker-Levy ($1991a_1$), (2) they were taken when these comets were at very similar distances from the sun and from the earth (R and Δ both near 0.9 AU), and (3) they were secured with the same instrument. Using the fluxes measured in the $\sim$ 1000 km $\times$ 3000 km aperture of the FOS and recently re-evaluated excitation rates for the CH A-X (0,0) band, the A-X (0-0) band of NH, and several bands of NH_2, we obtain average column densities for the radicals and derive production rates of their parents. These production rates are referred to that of H_2O, which itself is estimated using emissions from OH and [OI] that were recorded either simultaneously, or nearly so. Spectral synthesis is used to separate the forbidden oxygen line emissions from the superposed NH_2 features, while similarly, careful subtraction of the underlying continuum (using an appropriately convolved solar spectrum) is carried out in order to extract the relevant molecular fluxes. The influence of various model parameters (such as scale-lengths, time-scales, and velocities) on the derived relative abundances is discussed.

[1]On leave from the *Space Telescope Science Institute*

HIGH-VELOCITY EJECTION OF LARGE FRAGMENTS FROM ASTEROIDS IN NON-CATASTROPHIC IMPACT EVENTS: RESULTS FOR VESTA

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The recent confirmation of large impact fragments from the asteroid 4 Vesta (Binzel and Shu, 1993) has forced a re-evaluation of the impacts of asteroids. These "chips off Vesta" are small asteroids (~4-7km) bearing spectral signatures of basaltic achondrites whose proper elements e and sin$i$ are very close to Vesta's, and whose mean heliocentric distance a ranges from inside Vesta out to the 3:1 Jovian resonance. This is the route which takes these chips to Earth; Vesta (*c.f.* Drake 1979) is probably the ultimate Eucrite parent body. This large (~570 km diameter) parent asteroid was not disrupted by the impact which ejected these large and fast (~500 m/s) fragments; as such it is probably unique in the present Solar System. It is apparent (Gaffey, 1984) that Vesta has preserved its basaltic crust except in the hemisphere of a rather large impact event, indicated by a large region of exposed olivine.

The puzzling aspect of large, fast ejecta fragments from an undisrupted target can be summarized in very general terms as follows: Fast ejection velocities require a high impact velocity. High impact velocities result in large pressures and high strain rates. Large pressures and strain rates lead to *small* fragments. Furthermore, laboratory impact experiments seldom show large fragments traveling at any appreciable fraction of the impact velocity. But some fundamental aspects of the problem are ignored in this analysis: (1) a 4 km chip off Vesta is, to scale, only ~0.4 mm (smaller than an individual basalt grain) in a laboratory impact experiment; (2) spallation can double the ejection velocities while maintaining relatively low shock pressure (Melosh 1985), and (3) the impactor may have been too large for point-source ejecta computations to be valid. Escape velocity on Vesta is ~350 m/s, such that fragmentation of the target does not imply its disruption. Large spall plates ejected at 50 m/s would, for example, fall back in nearly their original orientation. We shall address this issue with some planetary data and with hydrocode computations.

Vickery (1987) has shown, by measuring the diameters of secondary craters from large impacts on Mercury and on Mars, that a quantity of sizable ejecta ($\gtrsim$ 2 km) leaves large craters at high velocities ($\geq$ 500 m/s). Consider for instance Lyot, a 200 km crater formed on Mars (transient diameter D_t ~ 150 km). Assuming an impact speed of ~8 km/s, gravity scaling (Schmidt and Housen 1987) tells us that the impactor diameter was ~15 km, assuming the same density (2.7 g/cc) for both target and impactor.

Gravity plays a considerable role in the formation of this crater bowl on Mars, yet the ejection of spall fragments is due solely to the immediate effects of the passing shock and is not strongly effected by gravity. Thus, if Vesta can withstand this same impactor without disrupting (and without the dispersal of its basalt crust), then the range of fragment sizes and velocities which formed at Lyot can be expected. To test this hypothesis, we conducted a hydrocode experiment with this equivalent impactor at the same velocity. Vesta survived this impact without any hint of catastrophic disassembly. We ran experiments with impactors as large as 60 km diameter at 8 km/s impact speeds without resulting in the breakup of Vesta.

Several hydrocode fragmentation models shall be presented, for a variety of initial Vestas, including a solid body, a strongly heterogeneous target, and a target with a strong crust and weak interior. In each case some large material (~2 to 10 km) is ejected at escaping velocities ($\gtrsim$ 350 m/s).

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METEOROIDS

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A brief review of available data on the structure and composition of meteoroids, obtained mainly from photographic observations of meteors, is presented.

The fact of meteoroids' fragmentation in the Earth's atmosphere was registered repeatedly by means of different observational methods and especially by the photographic method of instantaneous exposure. Four principal forms of fragmentation is established, among them the quasi-continuous fragmentation, i.e. a gradual release of small fragments from the surface of the parent meteoroid and their subsequent evaporation, is most spread.

The analysis of photographic observations of meteors shows that about 30 per cent of meteoroids undergo a quasi-continuous fragmentation. Not only porous and crumbly meteoroids are subjected to fragmentation in the atmosphere but more dense stony and iron-stony meteoroids, as well. Taking into account the quasi-continuous fragmentation, by mathematical simulation of photometric light curves of meteors and by that of meteoroids' decelerations in the atmosphere the densities of more than 300 meteoroids have been determined by present, which vary in the range from 0.2 to 8 g/cm^3.

It is of special interest the meteors registered at anomaly high altitudes because it was proposed that such meteors were produced by meteoroids, which contain the organic compounds.

IDENTIFICATION OF SMALL DUST IMPACTS IN THE ULYSSES AND GALILEO DUST DATA

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Two similar dust detectors on the Galileo and Ulysses spaceprobes registered dust impacts for over 3 and 2 years, respectively, traversing radial distances from 0.7 to 5.4 AU. The instruments are multi-coincidence impact ionization detectors. The amplitudes and risetimes of the charge signals obtained from an impact allows us to derive masses of dust particles ranging from 10^{-16} g to 10^{-8} g with an error of aproximately factor 10 and speeds above 2 km/s with an error of approximately factor 2. All impact and noise signals are divided into amplitude and quality classes which refer to coincidences between the different signals. The two lowest signal amplitude and quality classes are contaminated by noise events triggered e.g. by solar UV flux or energetic particles. For this reasons all events classified in these classes had been discarded so far. The number of small particles with masses less than 10^{-12} g (at 20 km/s speed) is affected by this selection. A close analysis of the signal properties of small events shows that, nevertheless, noise can be reliably discriminated from impacts in these lower classes. The distribution of dust particle masses follows a power law, therefore, the total number of identified dust impacts increases by about a factor of two. This increased number of impact events allows us a better definition of the distribution of particle properties. An example are the 'Jupiter dust streams' [1] registered by the Ulysses detector at a distance from Jupiter ranging from about 0.5 AU before to 1 AU after the flyby in February 1992. Since these streams consist of very small particles throughout many additional particles could be identified (factor 3 more). The already known streams show up even more strongly and additional streams can be seen before and after the the Jupiter flyby. Improved mean values for mass, speed and impact direction of the stream particles and mean time and duration of the streams are derived. This may help to better understand the source and the emission mechanism of this new phenomenon.

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ION IRRADIATION EXPERIMENTS RELEVANT TO THE PHYSICS OF MINOR OBJECTS IN THE SOLAR SYSTEM

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Ion irradiation experiments on astrophysical relevant targets have been conducted for more than one decade in our laboratory. The relevance of the results for the cometary physics (e.g. Strazzulla and Johnson 1991) and the reflectance properties of asteroids and other small objects (e.g. Andronico et al. 1987) have been assessed.

In this paper we present new experimental results concerning:

-Production of new species (including CO, CO_2 and CH_4) from irradiated frosts (among which CH_3OH+H_2O mixtures).

-Changes in the sublimation properties of irradiated ice mixtures (including CO and H_2O).

The results are discussed in the light of their potential ability to predict molecular ratios (e.g. CH_4/CO) on cometary nuclei and contribute to a better knowledge of cometary formation processes and subsequent evolution under the influence of external agents such as cosmic ion irradiation and thermal cycling.

This research has been supported by the Italian Space Agency (ASI).

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CCD REFLECTANCE SPECTRA OF APOLLO ASTEROID 4179 TOUTATIS.

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Low-resolution spectra were obtained for the Earth-crossing asteroid 4179 Toutatis during its 1992-93 close encounter with the Earth.
The latest Toutatis apparition has represented an extraordinary opportunity for observations and investigations of a small body as this event has been the closest approach of any known minor planet or comet between now and 2000. In the campaign organized around the world to observe the asteroid Toutatis, our group observed it spectroscopically in the visible on September 27th and 28th 1992 at ESO-La Silla (Chile) when it was at Δ=0.410 AU from the Earth and on January 4th and 5th 1993 (Δ=0.185 AU) at the Asiago Observatory (Italy) obtaining a total of 35 spectra. The reflectance spectra were acquired using the 2.2m telescope + CCD/EFOSC2 combination at La Silla and the 1.82m telescope + CCD/Boller & Chivens combination at Asiago. The EFOSC2 spectrograph was equipped with a 300 ll/mm grating covering a spectral range 3500-9000 Å; the B&C spectrograph with a 150 ll/mm grating covering a spectral range 3700-7800 Å. Bias, flat-field, calibration lamp, standard stars and solar analogs were secured in order to wavelength and flux calibrate the asteroidal spectra and to eliminate the solar contribution. The reduction is still in progress and at present data from ESO 2.2m telescope have been reduced with the MIDAS package. The principal aim of the analysis of these spectra is to investigate the surface composition of the asteroid in an effort to learn about its origin and formation and, more generally, of the AAA asteroids and their possible relation with cometary nuclei.

4179 TOUTATIS

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An international campaign has been organized around the word to observe the asteroid 4179 Toutatis (1989 AC) during December 1992 (closest approach Dec. 8th within 0.024 A.U. of the Earth) and January 1993. Our group participated to observe it with continuous runs starting December 7th, until the end of January 1993. We obrained CCD photometric data for 30 nights taken at Haute Provence, Pic du Midi and Asiago Observatories.

Our first observations, obtained at ESO during last summer, seem indicate a very slow rotator asteroid. The results from first radar observations made by S. Ostro from Arecibo and spectrophotometric observations made by D. Tholen from Hawaii Observatory, seem indicate a S type object having a "contact binary" shape with component diameters of 4 and 2.5 Km respectively.

The aim of our work is to have a precise determination of the rotational period, variations of the lightcurve shape as it moves acrosss the sky, determination of the inclination of the rotation axis and the shape of the asteroid. In addition our aim is to performe a photometric observation at different phase angle to obtain a good phase-function. Toutatis passes through a minimum solar phase angle of less than 0.25 degrees, so the phase function can exibit the "opposition spike" and the the detailed shape of the phase function may give information on surface morphology and regolith.

As done for the asteroid 951 Gaspra (Barucci et al. 1992) we will use the results of the observations to obtain a model of 4179 Toutatis inverting the available lightcurves. The comparison of the obtained model with the radar images will represents the second check on the quality of the inversion methods.

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Title : Origin of comets of the Jupiter family

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ABSTRACT : The hypothesis of complete capture of nearly parabolic comets into short-period comets by a single quasi-collisional encounter with Jupiter is considered. The shock would be treated as a single velocity impulse applied tangentially to the initially open orbit at its perihelion becoming the aphelion of the captured orbit.

C. Edelman has shown in a previous work that this ideal capture mechanism does not contradict the distribution of orbital elements of the Jupiter Family of comets observed before 1984. In addition, the single captured orbit (modulo the orientation) resulting from the testing procedure, suggests the break-up due to Jupiter of some large incoming giant nearly parabolic comet.

The validity of the present assumption as regards capture with such a shock with Jupiter is examined for comets observed after 1984 whose perihelia are diversified. Once more the ideal capture scenario and the break-up hypothesis are not contradicted by the observations.

DETERMINATION OF MASSES OF MAIN MINOR PLANETS

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ABSTRACT

The equations of the motion of the minor planets are function not only of the initial orbital elements but also of the masses of the disturbing bodies. Therefore, the values of the masses of the main minor planets are determined when the system of the equations of the motion for Hipparcos minor planets is solved by using observations of minor planets, specially all the observations made during the campaign of observations for Hipparcos.

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CoMA a High Resolution TOF-SIMS for In-Situ Analysis of Cometary Matter

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Abstract

Gathering informations about comets up to now mainly has been a domain of astronomical techniques. Only recently first in-situ analysis could be performed when the flybys of the VEGA and GIOTTO space probes enabled close-up explorations of comet Halley (Kissel et al., 1986). Further missions to comets they are in discussion within ESA (ROSETTA) as well as within NASA's DISCOVERY program for small missions (CONTUR, SMACS) will give new insights in these one of the most pristine bodies of our solar system.

A high resolution **T**ime-**o**f-**F**light **S**econdary **I**on **M**ass **S**pectrometer (TOF-SIMS) developed as a **Co**metary **M**atter **A**nalyser (CoMA) will present. First results of this device were given by Zscheeg et. al., 1992. TOF-SIMS is a very useful mass spectrometer for space applications. In this device a new kind of very well space tested liquid metal ion source for the pulsed microprobe is used (Beck, 1992).

This TOF-SIMS enables to analyse µm-sized cometary dust grains and cometary gases with high mass resolution. It makes it possible to yield data about elements, isotopic and molecular composition. As interferences by isobaric molecules are reduced because of the high mass resolution of CoMA, the isotopy of those elements will severely constrain the boundary condition of models which describe origin and evolution of comets. The device's mass range of up to 3000 will give insight in detailed analysis of organic cometary constituents to study their processes.

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Physical properties of M-type asteroids

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Abstract

The number of asteroids claimed to be of type M is presently 61 objects but for about ten of them the classification is uncertain. We have compared the mean values and dispersions of the main physical characteristics of the M-type asteroids with the corresponding properties of C and S asteroids in order to understand their real differences and homogeneity. All chosen C and S asteroids have diameters and orbital semi-major axes in the same range as the considered M asteroids (30-260 km; 2.3-3.2 AU). The following physical parameters were considered: UBV and JHK colours, ECAS colours, albedo, the depth of the negative polarization branch P_{min}, rotation period, lightcurve amplitude and the Fourier coefficients of well-defined lightcurves. Statistically meaningful differences in the mean values of M-type objects as compared to the C and S populations were found in the ultraviolet (U-B, u-v, s-v) and red (v-w, v-x) colours, albedo and P_{min}. These are the most informative characteristics distinguishing M-type asteroids from others. One way to enlarge the population of the M-type could be to observe any of these colours for the about 300 unclassified asteroids with moderate IRAS albedos. The fast rotation and large lightcurve amplitudes of the M-type asteroids were confirmed. Variances of all parameters were compared between different asteroid classes. The population of M-type asteroids turned out to be more homogeneous than the S class.

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SMACS: SMALL MISSIONS TO ASTEROIDS AND COMETS.
A Fast, Low cost Approach to the Space Reconnaissance of Near-Earth Objects

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ABSTRACT

SMACS (Small Missions to Asteroids and Comets) is a NASA / DISCOVERY-class mission candidate that will rapidly and efficiently expand the scientific reconnaissance of asteroids and cometary nuclei begun by the Galileo, Giotto, and VEGA missions. The concept is to target a series of small spacecraft to carefully selected taxonomic types of near-Earth asteroids (NEA's) and cometary nuclei (CN) to perform a comparative remote sensing reconnaissance of their physical and chemical properties. The intent is to perform a reconnaissance of the full range of known types and evolutionary states in as few missions as possible and at the minimum expense. SMACS also includes international participation to extend the concept to as wide a range of measurement techniques as is feasible.

The SMACS mission will initiate this effort with separate launches of four small spacecraft on low-cost Pegasus XL boosters. The first is to 2100 Ra-Shalom (a primitive C-type asteroid); the second to 1986 DA (an M-type asteroid thought to be a fragment of the exposed core of a differentiated parent body); the third to P/Finlay (a CN probably in an intermediate stage of evolution); and a fourth to 3200 Phaethon (an F-type and a strong candidate for an extinct comet in the final stage of CN evolution). Successful encounters with these targets should immediately yield any distinctive physical and chemical differences that exist between each of them and with the range of S-types observed from Galileo (951 Gaspra and 243 Ida) and the active CN, P/Halley, observed from Giotto / VEGA. After completing its prime mission, each spacecraft may be available for an extended mission to another near-Earth object (NEO). Possible extended missions include one to a rare V-type (3361 Orpheus). Each encounter is in the flyby mode and is accomplished with a low-cost, 3-axis stabilized spacecraft with an advanced technology, high-resolution (5-14 rad/pixel), large-format (2048 x 2048), charge-coupled device (CCD) camera fully integrated into the attitude control system. A second instrument will be considered for each flight depending on an analysis of mass and cost margins and the possibility for international cooperation. The encounters will be largely autonomous and self-sequenced. Spatially resolved images in nine spectral bands (350-1000 run) will be acquired over a full rotation period and a range of phase angles, giving an approximately global view of the surface morphology, data on mineralogical and physical heterogeneity, stereo information on localized topography and spin, and photometric information on regolith or surface microstructure characteristics. Surface resolutions up to 8 m/pixel will be obtained.

Single-string systems will be used to reduce cost. Redundancy against mission failure and cost overruns is provided by separate launches. Redundancy against mass growth is provided by the ability to move to lower C_3 targets. Launch support, communications, and mission planning will be the responsibility of the Jet Propulsion Laboratory; spacecraft development will be the responsibility of Ball Aerospace; and the camera development and integration will be the responsibility of Malin Space Science Systems. The total development cost for the four flights is estimated at $139M including reserves. The first mission costs $64M with the additional three missions averaging $25M each.

STOCHASTICITY OF COMET P/GE-WANG

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Three comets are now known to be at or near the 1/1 resonance with Jupiter: P/Slaughter-Burnham, P/Boethin and P/Ge-Wang. Although details of the individual orbits differ, the three comets have very similar general dynamical behaviour: their orbits show many transitions between the different types of resonant motion (satellite and anti-satellite librations, and circulation).

The stochastic character of such cometary orbits, mainly due to encounters with Jupiter, is investigated using Lyapunov Characteristic Indicators. For each comet of the group, we study the influences of initial mean anomaly, eccentricity and inclination on the stochasticity of the orbit.

P/Slaughter-Burnham and P/Boethin have been previously studied.

We present here our first results for P/Ge-Wang.

CHIPS OFF OF 4 VESTA: A NEWLY CONFIRMED ASTEROID FAMILY AND LINK TO BASALTIC ACHONDRITE METEORITES

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Because of its unique spectroscopic signature, asteroid 4 Vesta makes an ideal test case for studying major impact events which may excavate large fragments from planetary surfaces. Assuming that fragments from Vesta retain a basaltic spectral signature (deep pyroxene absorption band near 9000Å) similar to their parent body, they may be readily distinguished from other asteroids even if they happen to be located far from Vesta. Predictions for an asteroid family related to Vesta date back to work by Williams in 1979 and 1989 (1,2). However, predictions for a large membership within a possible Vesta family were first published by Zappalà et al. 1990 (3). Continuing work by Williams (4) also predicted many members within a potential Vesta family.

The prediction of this large Vesta family membership was coincident with the establishment of the first capability to routinely examine the spectral properties of such small D<10 km asteroids, having V magnitudes typically ranging from 16 to 18. The Small Main-Belt Asteroid Spectroscopic Survey (SMASS) is being conducted with a CCD spectrograph on the 2.4-m Hiltner telescope at the Michigan-Dartmouth-MIT Observatory located at Kitt Peak, Arizona. An examination of the spectral properties of predicted Vesta family members became one of the initial objectives of the SMASS program.

Over the last two years, we have examined 15 predicted Vesta family members (1-4) and found that 12 display basaltic achondrite spectral properties similar to Vesta itself (5). Given their spectral similarities and predicted dynamical association, we believe these $D \leq 10$ km asteroids represent fragments genetically related to Vesta itself. Thus these 12 asteroids, 1906, 1929, 1933, 2590, 3155, 3268, 3657, 3944, 3968, 4038, 4147, and 4546 represent the first physically confirmed members which conclusively establish the reality of a Vesta family.

An additional 8 small ($D \leq 10$ km) basaltic achondrite asteroids have been discovered between Vesta and the 3:1 resonance. We believe these asteroids (1273, 2011, 2113, 2442, 3153, 3869, 4005, and 4215) are also genetically related to Vesta and thus constitute additional family members. Their locations, bridging the space between Vesta and the 3:1 resonance, has other significant implications. Vesta has been at the center of the debate over the source of the howardite-eucrite-diogenite (HED) meteorites since the early 1970s (6,7) and the 3:1 resonance is a major dynamical transport region to the inner solar system. Despite its unique compositional match to HED basaltic achondrite meteorites, substantial dynamical difficulties in delivering fragments from Vesta to the resonance (7) have precluded any conclusive HED parent body link. However, the current orbits for these additionally discovered Vesta fragments imply ejection velocities in excess of 700 m/sec. Smaller (~1 km) fragments can therefore be expected to have been ejected with velocities ≥1 km/sec, sufficient to reach the 3:1 and ν_6 resonances. Thus it now appears to be dynamically viable for Vesta to be linked as the HED meteorite parent body.

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ASTEROID 243 IDA AS A MEMBER OF THE KORONIS FAMILY: PREDICTIONS AND IMPLICATIONS FOR THE GALILEO ENCOUNTER

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The Galileo spacecraft encounter target 243 Ida is a member of the Koronis family, one of the first families recognized by Hirayama early this century. As a member of one of the most firmly established families, *in situ* measurements of Ida will provide a valuable insight into the outcomes of catastrophic disruption events. The benefit of Ida's membership in a well-defined family is that with reasonable confidence we can identify other asteroids that were created at the same time and location as Ida. Thus results from *in situ* measurements for the formation age and collisional history of Ida can be readily extended to a whole family of other bodies.

We are conducting a complementary study of the Koronis family in order to provide the best context for interpreting the Galileo Ida results. Specifically, we are continuing observations to study the distribution of rotation rates, inferred shapes, and spin vector orientations of a large sample of Koronis family members. Work to date (1) has suggested that the Koronis family may have formed relatively recently compared to the age of the solar system, perhaps within less than 10^9 years. We are investigating whether a possible preferential orientation of Koronis family spin vectors, which would imply a recent formation, proves to be significant when the sample size is increased.

In addition to physical studies of Koronis family members to investigate their collisional history, we can also estimate the relative collisional history of Ida with respect to 951 Gaspra, based on the known population statistics within the main belt. The mean intrinsic collisional probability for Ida is estimated to be 5.0×10^{-18} km^{-2} yr^{-1}, comparable to Gaspra (2). The impactor velocity distribution for Ida, however, shows a lower velocity tail than for Gaspra, owing to its more planar and circular orbit. Potential Ida impactors have a mean encounter velocity of 4.3 km sec^{-1}. In addition, the number density of potential impacting asteroids in Ida's vicinity is about 150% greater than for Gaspra.

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Photoelectric observations of 4179 Toutatis.

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The results of B and V photoelectric observations obtained at Serra La Nave stellar station of Catane Astrophysical Observatory over five nights during the recent passage of 4179 Toutatis are reported. From the analysis of our data and those from "Toutatis news" some tentative values of the rotational period have been deduced.

Observations of OH in P/Swift-Tuttle and in several recent weak comets with the Nançay radio telescope

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The OH radio lines at 18 cm were monitored in six comets with the Nançay radio telescope in 1992 and early 1993: Zanotta-Brewington 1991g1, Bradfield 1992b, Mueller 1991h1, Shoemaker-Levy 1991a1, P/Swift-Tuttle 1992t, and P/Schaumasse 1992x.

Neither Bradfield 1992b nor Mueller 1991h1 could be detected. Zanotta-Brewington 1991g1, Shoemaker-Levy 1991a1 and P/Schaumasse 1992x were relatively weak comets whith OH production rates of the order of 10^{28} s^{-1} and required several hours of integration to be detected.

P/Swift-Tuttle was observed and detected as soon as mid October 1992. The signal was much stronger than for the other comets, especially at the beginning of December 1992, when P/Swift-Tuttle was observed against galactic background radiation. The OH production rate was several 10^{29} s^{-1}. All along the observations, the OH radio lines exhibited unusually high blueshifts, corresponding to gas bulk motions of 0.5 to 1.0 km s^{-1} towards the observer. This undoubtedly corresponds to the strong jets observed in optical images and to the important non-gravitational forces that affect the orbit of this comet. P/Swift-Tuttle was still observed at Nançay at the beginning of January 1993 when the small solar elongation precluded optical observations.

A summary of these observations and of the estimations of the OH production rates will be presented.

The Origin of the 3.2-3.6 micron Emission Features in Comets: Gas or Dust

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Using an infrared fluorescence model, we investigate the contribution of the ν_2, ν_3 and ν_9 methanol bands to the 3.2-3.6 μm organic emission feature observed in seven comets: P/Halley, Wilson 1987 VII, Bradfield 1987 XXIX, P/Brorsen-Metcalf, Okazaki-Levy-Rudenko 1989 XIX, Austin 1990 V and Levy 1990 XX. In 4 comets, the flux observed from 3.3 to 3.4 μm is almost completely explained by methanol. The 7 comets present residual spectra with a distinct emission feature extending from 3.38 to 3.5 μm and centred on 3.428 μm ($\sim$ 2920 cm^{-1}). The flux of this 3.43 μm feature is strongly correlated with the water production rate, suggesting a gaseous origin with organics present at comparable abundances from comet to comet. From an inspection of the laboratory spectra of small organic molecules, no definite identification can be found. Four comets (P/Halley, Wilson 1987 VII, Bradfield 1987 XXIX and Levy 1990 XX) show a large emission excess in the 3.2 - 3.3 μm spectral region corresponding to the signature of unsaturated aromatic organics. In the present sample, these comets are those presenting high dust-to-gas ratios, as measured in the UV.

Observations of sub-millimetre lines of CH_3OH, HCN and H_2CO in comet P/Swift-Tuttle with the James Clerk Maxwell Telescope

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Sub-millimetre molecular line observations of comet P/Swift-Tuttle were undertaken on December 6, 7 and 8th 1992 with the James Clerk Maxwell Telescope at Mauna Kea. Hydrogen cyanide (HCN), formaldehyde (H_2CO) and methanol (CH_3OH) were successfully observed.

HCN was detected through its J=4-3 rotational line at 354.505 GHz. The antenna temperature reached 2.5 K and the signal-to-noise ratio was close to 90. To our knowledge, this is the strongest radio signal ever recorded in a comet. Formaldehyde was observed through its 5(1,5)-4(1,4) line at 351.77 GHz with a signal-to-noise of about 15. Methanol was detected for the first time at submillimetre wavelengths, through at least 7 of its J=7-6 rotational transitions at 338 GHz and one line at 341.42 GHz. The analysis of the relative intensities of the CH_3OH lines will give stringent constraints on the excitation conditions of methanol in the coma. A preliminary study suggests that the J=7 rotational levels are populated according to a Boltzmannian distribution at the temperature of 50 K.

As preliminary estimates the observed line intensities correspond to HCN, H_2CO and CH_3OH production rates of 1. 10^{27}, 5. 10^{27} and 2. 10^{28} s^{-1} respectively, if direct release from the nucleus is assumed. Given the OH production rate of 5. 10^{29} s^{-1} measured in the UV and the radio, we deduce HCN and H_2CO abundances relative to water of 0.2 and 1% respectively. The high abundance measured for CH_3OH (4%) confirms that this species is an important constituent of cometary atmospheres whose abundance is variable from comet to comet.

All the detected lines are highly asymmetric in shape and strongly shifted towards the blue. Such an asymmetry is indicative of strong anisotropic outgassing towards the Sun and can be correlated with the morphology of jets of the inner coma observed in the visible.

ASTROMETRIC MEASUREMENTS OF MINOR PLANETS IN 1991 - 1992

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Abstract. In this paper , minor planets precise positions observed in 1991 - 1992 are presented.

keywords: photographical astrometry , minor planet

I. INSTRUMENTAL TECHNIQUE

For performing the observations , a 360/6000 mm astrograph was used, with 2x2 square degree field and an ORWO ZU 21 , 24x24 cm plates were exposed . The measurements of the plates were carried out with an ASCORECORD Carl-Zeiss measuring machine . Computations were done with an PC IBM 386 AT .

II. THE PROCEDURE

The observations were made by two methods : Metcalf's method and blinking - double exposures method . The positions were calculated using five reference stars from STAR CATALOG (SAO) or PPM STAR CATALOGUE . The programme was conceived in the Astronomical Institute of the Romanian Academy.

III. RESULTS

The table give a synthesys of this work . For each minor planet the table includes the following columns: name of asteroid , date of observation , correct values for U.T., right ascension and declination , name of the reference stars catalogue and the method used.

Astrometric Measurements; G. Bosca and M. Birlan

1991

No	PLANET	U.T.	α_{1950}	δ_{1950}	STAR	METHOD
3	JUNO	sept, 9.760718	19 00 31.674	-10 27 51.56	SAO	D.E
3	JUNO	sept, 9.774569	19 00 31.715	-10 27 56.53	SAO	D.E
3	JUNO	sept,12.774084	19 00 52.744	-10 46 23.85	SAO	D.E
3	JUNO	sept,12.787843	19 00 52.853	-10 46 28.72	SAO	D.E
6	HEBE	sept, 9.846594	22 21 21.516	-20 48 37.24	SAO	D.E
6	HEBE	sept, 9.854905	22 21 21.200	-20 48 44.27	SAO	D.E
6	HEBE	sept,10.818581	22 20 43.991	-21 01 20.62	SAO	D.E
6	HEBE	sept,10.826891	22 20 43.660	-21 01 26.75	SAO	D.E
7	IRIS	sept,10.838664	22 46 49.450	4 03 38.84	SAO	D.E
7	IRIS	sept,10.844205	22 46 49.149	4 03 36.87	SAO	D.E
7	IRIS	sept,26.763465	22 33 56.010	2 29 36.00	SAO	D.E
7	IRIS	sept,26.769698	22 33 55.735	2 29 33.57	SAO	D.E
7	IRIS	sept,27.787404	22 33 16.472	2 23 08.50	SAO	D.E
7	IRIS	sept,27.792945	22 33 16.240	2 23 07.07	SAO	D.E
7	IRIS	sept,30.811413	22 31 29.795	2 04 13.10	SAO	D.E
7	IRIS	sept,30.818338	22 31 29.531	2 04 10.67	SAO	D.E
7	IRIS	oct , 7.827272	22 28 27.070	1 22 13.83	SAO	D.E
7	IRIS	oct , 7.836275	22 28 26.879	1 22 10.45	SAO	D.E
39	LAETITIA	sept, 9.737864	18 24 26.576	-15 02 31.33	SAO	D.E
39	LAETITIA	sept, 9.748945	18 24 26.864	-15 02 34.56	SAO	D.E
39	LAETITIA	sept,10.742054	18 24 55.979	-15 07 31.64	SAO	D.E
39	LAETITIA	sept,10.753135	18 24 56.300	-15 07 35.21	SAO	D.E

1992

3674 ERBISBUHL

U.T.	α_{2000}	δ_{2000}	CATALOG	METHOD
sept,24.830573	0 38 28.587	58 24 19.84	PPM	METCALF
sept,24.847194	0 38 25.043	58 24 26.24	PPM	METCALF
nov ,16.786250	0 24 45.968	58 58 06.87	PPM	METCALF
nov ,16.798716	0 25 10.402	58 57 32.03	PPM	METCALF

Concerted Elemental Analyses – PIXE and TOF-SIMS – of Interplanetary Dust Particles

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Interplanetary dust particles (IDPs) collected in the terrestrial stratosphere – beside meteorites and lunar material – constitute the third kind of extraterrestrial matter available for laboratory study. *Per se* these particles thus are interesting objects and more so, since they may be linked to comets. However, because they are small (typical dimension 10 μm) they are difficult to analyse, especially when it comes to minor and trace elements. In the past we had implemented Proton-Induced X-Ray Emission (PIXE) and Synchrotron-Fluorescence-X-Ray Analysis (SYXFA) techniques [1–6] and the latter also was heavily used by others [7–13]. More recently we explored and used the tremendous capabilities of Time-of-Flight SIMS (TOF-SIMS) for analysis that are exemplified by high lateral resolution (≈0.2 μm) and high sensitivity. Here we report on both, new TOF-SIMS analyses and first results obtained with the newly constructed Heidelberg-Micro-PIXE (lateral resolution ≈1 μm).

A striking feature of many IDPs is the large (up to 100×) bulk enrichment – relative to cosmic abundance – of some volatile elements, especially Br. It had been argued that this feature is signifying a new kind of extraterrestrial matter [13]. We contended, however, that before far reaching conclusions on the composition of major portions of the solar system are drawn, one would have to examine if the enrichments indeed are indigenous and would have to exclude that they are related to the likely contaminating atmospheric processes [14,15]. The most striking result of our present investigations using both PIXE and TOF-SIMS is the clearl demonstration that elements, that are present in non-cosmic abundance, are distributed very inhomogeneously within IDPs. In one IDPs for example Br is enriched in extremely fine grained (≈20 nm) Fe-rich portions that appear to be most susceptible for reactions with atmospheric aerosols. In another IDP all elements that in the bulk are present in cosmic abundance are homogeneously dispersed while the concentration profiles of some of those elements that are either enriched (Cu, Co, Cr) or depleted (Ca) in bulk relative to CI chondrites deviate from homogeneity.

We are aware that the present data set on IDPs – and especially the very limited data on minor and trace element *distributions* within them – is far from being complete and certainly do not allow to be firm on the origins and histories of individual IDPs, but we also are convinced that the results of such analyses ultimately will provide rigourous boundary conditions for both.

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DYNAMICAL EFFECTS OF ASYMMETRIC NONGRAVITATIONAL FORCES ON LONG-PERIOD COMETS

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The model of asymmetric nongravitational forces developed by Yeomans & Chodas (1989) is used to investigate their perturbing effects on the orbital energy $(1/a)$ of long-period comets. Results are presented for different combinations of light-curves asymmetries, lag angles, force magnitudes and perihelion distances. It is found that the change in $1/a$ after a perihelion passage strongly decreases with the perihelion distance q, and this perturbation turns out to be significant only for comets approaching the Sun to less than a few tenths AU.

Comparison of our results with the observations in the scatter of the original values of $1/a$ of near parabolic comets ($-5 \times 10^{-4}\mathrm{AU}^{-1} < (1/a)_{orig} < 5 \times 10^{-4}\mathrm{AU}^{-1}$) suggests that they are not significantly affected by nongravitational forces and in general they may be comparable to those found in periodic comets.

Images of comet Swift-Tuttle 1992t in the light of H_2O^+ and CO^+ ions, and dust

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The ions of water and carbon monoxide are believed to originate in the coma of comets by different mechanisms. The main channel for generation of H_2O^+ is photoionization of H_2O. The main loss mechanism for H_2O is photodissociation. Therefore this mechanism determines the extent of the H_2O^+ source region. CO is much more difficult to photodissociate than water. Therefore the CO^+ source is more extended. But CO^+ is not only produced by direct photoionization of CO, but also by dissociative ionization of CO_2 and by an unknown extended source, possibly related to the dust. Ionization by charge exchange with solar wind protons is also more important for CO^+ than for H_2O^+. It is therefore of interest to determine the extent of the H_2O^+ and CO^+ comae in comets.

Comet Swift-Tuttle was observed with the 2m-RC-telescope of the Bulgarian National Observatory and the focal reducer of the Max-Planck-Institute for Aeronomy in the evenigs of November 24, 25, and 28, 1992, when the comet was at a heliocentric distance of 1.0 AU and a geocentric distance of 1.3 AU. We obtained images through interference filters centered at 619.5 nm ($\tilde{A}\,^2A_1 \rightarrow \tilde{X}\,^2B_1$ 0–8–0 transition, H_2O^+), 426 nm ($A\,^2\Pi_i \rightarrow X\,^2\Sigma^+$ 2–0 transition, CO^+) and 642 nm (dust continuum window) with a width (FWHM) of ≈ 3 nm. Some images taken through a filter centered at 500 nm with the same width show the C_2 coma and dust. Using the images taken at 642 and 500 nm we make an attempt to remove dust and C_2 coma (emission at 618.9 nm) from the plasma images to reveal the plasma distribution in the inner coma. The resulting cleaned images will be presented and compared with the aim to detect differences in the spatial distribution of CO^+ and H_2O^+. As a by-product of this study we will also derive the dust distribution and its colour variation in the cometary coma.

Two components in meteor spectra

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Analyzing a spectrum of a bright fireball, it was found that the brightness of about 300 lines can be explained assuming the temperature of 4400 K and thermal equilibrium. However, observed lines of Si II and Mg II should not be visible under such conditions at all. Their presence is an evidence for another radiating region in the meteor. Indeed, assuming two regions with identical chemical composition and temperatures 4400 K and 10 000 K respectively, the spectrum can be completely explained.

The high temperature component will be called "the second spectrum". I presume its origin in the shock wave. For the 17 km/s fireball the mass ratio of low temperature to high temperature gas is approximately 6000:1, but it was shown that the importance of the second spectrum raises with increasing meteor velocity. Both regions must be strictly divided, though they cannot be resolved spatially from observations (as e.g. wake can).

The figure shows typical lines of the second spectrum. Also the well known infrared lines of oxygen and nitrogen belong to the second spectrum. The only lines common for both spectra are the lines of ionized calcium. Typical lines of the main spectrum comprise lines of neutral Na, Mg, Fe, Cr, Ca, and Mn.

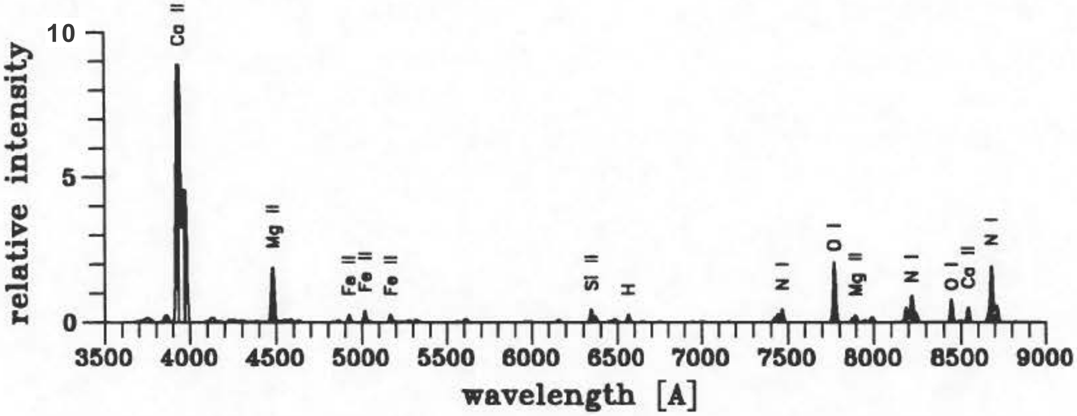

Figure. Typical lines of the meteor second spectrum. Synthetic spectrum of a gas containing 95% of air and 5% of meteoritic material under the temperature of 10 000 K is presented.

CCD IMAGING OF THE INNER COMA OF COMET P/HALLEY

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195 images of the inner coma of comet P/Halley were taken between March 3rd and March 23rd, 1986, using a charge coupled device (CCD) at the prime focus of the Anglo-Australian Telescope (Siding Springs, New South Wales, latitude −31.277°, longitude 149.066° E, elevation 1164 m). The complete images subtended an area of coma 4.2 x 2.6 arc mins such that each pixel in the 512 x 320 pixel array recorded an area of 0.49 arc secs square.

The library contains images taken using the eleven filters that were aboard Giotto as part of the Halley Multicolour Camera. The exposure time for each image was varied to ensure a good signal to noise ratio depending upon the filter passband and the part of the coma under investigation. All the images were then bias subtracted to eliminate any 'thermal signal' and flat-field corrected to ensure that there were no pixel to pixel sensitivity variations. For the purpose of this investigation we selected 23 images that were taken using either the red continuum or the C_2 filter. The study concentrated on the very innermost 59 x 59 block of pixels centred on the nucleus pixel. After the average background had been removed from the images (see A'Hearn *et al*,1986), areas of higher than average brightness were analysed. In particular, the position, dimensions and curvature of each feature were measured.

By employing a simple one-dimensional rotating jet model we found that the characteristics of the features observed on March 11th and 12th could not be readily explained given a spin period of 7.4 days. However, results for $T = 2.2$ day were more encouraging and we discovered that the characteristics could be emulated using the model if the emission latitude, $\lambda \leq 30°$ and the aspect angle (between the line of sight and the cometary spin axis), θ was constrained such that $55° \leq \theta \leq 90°$.

ASTEROID BAYESIAN ORBITAL ERROR ANALYSIS: APPLICATIONS

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We summarize recent progress in our work on the determination of asteroid orbits by applying Bayesian probabilities to optical astrometry. Although we determine orbits in the historically accepted way (least-squares differential correction), we regard the orbital elements as probabilistic rather than deterministic. Our protocol has spawned a variety of applications, among which are:

• *Orbit Refinement.* We have discussed short-term (days), medium-term (single-apparition), and long-term orbital and ephemeris accuracy, together with optimizing future observing strategy, in a paper in press in *Icarus.* Preprints will be available.

• *Orbital Element Database.* We plan to recompute all asteroid orbits, and to make available a public-domain orbit database via ftp (cf. Bowell and Muinonen, this conference). Associated with each set of osculating least-squares elements will be the orbital covariance matrix and metrics used to characterize orbital quality. As part of this work we will develop an automated method of orbit determination.

• *Criterion for Numbering Asteroids.* We recommend use of the so-called *leak*—longitude, eccentricity, and angular momentum ($\underline{k}$)—metric to decide whether an asteroid has been well enough observed for numbering. The leak metric correlates with an asteroid's ephemeris accuracy over a given interval.

• *Proper Element Computation.* We have devised a metric (termed the *sleak*, or simplified leak metric) that helps one decide whether the osculating elements of single-apparition asteroids are accurate enough to warrant computation of proper elements (cf. Milani *et al., op. cit.*).

• *Recovery Strategy.* By estimating an asteroid's sky-plane uncertainty as a function of time, one can decide when observational opportunities will arise for an asteroid's recovery, and whether narrow- or wide-field searches are appropriate. Searches for lost asteroids, such as (719) Albert, can be carried out largely using archive plates by accumulating evidence that a lost asteroid was *not* in various parts of its orbit at given times.

• *Planetary Collision Probability.* It is particularly important to assess the hazard due to near-Earth objects (NEOs). We start by defining the a posteriori probability density, define the collision probability, and then use the change in orbital χ^2 as a measure of NEO-Earth proximity over a given interval.

• *Asteroid Mass Determination.* Rather than use the dynamics of a particular asteroid-asteroid encounter, we will identify all such encounters that may have produced observable effects, undertake astrometry using archive plates where necessary, and then use the Bayesian method to solve simultaneously for the masses of all the perturbers involved.

A PUBLIC–DOMAIN ASTEROID ORBIT FILE

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We plan to construct a file of J2000.0 osculating elements for all asteroids having reasonably calculable orbits. The file will be made accessible publicly via anonymous ftp (we regret that we do not in general have the resources to provide the file in other forms).

A precursor elements file has been set up for test purposes and distributed to a limited number of users. It currently contains osculating elements integrated to the nearest 100-day Julian date (JDT 2449100.5 = 23 Apr 1993 TT) of 5,493 numbered asteroids; 4,431 orbits of asteroids that have observational arcs of 75 days or more or that are near–Earth approachers ($q \leq 1.3$ AU); and 11,723 additional orbits of short-arc asteroids. In addition to number/name/designation and osculating elements, the file contains information such as perturbation scheme (e.g., Mercury through Neptune); publication history/orbit computer; H, G magnitude parameters; and flags that indicate Earth–crossing asteroid status, orbits for which uncertainly identified observations were used, and whether an asteroid was observed during a survey (PLS, T–1, T–2, T–3, and/or UCAS). We are updating the precursor file on an almost daily basis as new orbits are computed. Our principal criteria for orbit update are that no apparently satisfactory astrometric observations should exhibit great–circle residuals exceeding 4 arcsec (a somewhat arbitrary but computationally convenient threshold) and/or that the orbital arc be significantly extended by new observations.

For the future file, we will recompute osculating elements for all orbits so as to be able to incorporate orbital error parameters, such as the orbital element covariance matrix and various metrics relating to orbital accuracy that derive from the orbit determination method of Muinonen and Bowell (this conference, for example). The error parameters, generally computed for orbits derived from five or more observations, will allow users to estimate spatial and sky–plane uncertainties as a function of time, to decide whether the computation of proper elements is warranted, to design a recovery strategy, and so on. In addition, we will provide more complete documentation of orbits than is usually given. Following the publication of new observations, it will usually be possible to update orbital error parameters without recomputing an orbit. We expect the file itself to be updated every few days.

We invite potential users of the osculating element file to discuss its proposed content with us and to make suggestions for its improvement.

Disconnection Events (DEs) and Sector Boundaries: The Evidence from Comet Halley 1985-1986

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Cometary and solar-wind data for the interval December 1985 through April 1986 are presented for the purpose of determining the solar-wind conditions associated with DEs. This paper adds 3 DEs to the work of Yi et al. (1993) and now includes all 19 DEs believed to be "obvious" in comet Halley.

The 3 DEs have disconnection times of January 16.9, January 19.9, and March 11.4, 1986. Currently, all of these DEs have only a single image. The disconnection times are inferred from average kinematics for other DEs.

The solar-wind data come from IMP-8, ICE, PVO, and Vega-1; these spacecraft have been used to establish approximately 50 sector-boundary crossings and the velocity for this entire period came primarily from IMP-8. Sector boundaries at the sun (Hoeksema 1989) have been extrapolated into heliospheric space using measured solar-wind speeds and different source-surface radii to determine the 'best-fit' to the spacecraft data. This best-fit boundary is compared with the times and locations of DEs as are the times of high-speed streams.

DEs show a clear association with sector boundaries, but not with high-speed solar-wind streams. For example, the IMP-8 data for this time interval shows only 9 streams where the speed is 600 km/sec or greater. Thus, the DE mechanisms favored include those of Niedner and Brandt (1978) which invokes sunward magnetic reconnection and of Russell, Saunders, Phillips and Fedder (1986), if sector-boundary crossings can trigger tailward magnetic reconnection. If the DE locations are shifted by an amount corresponding to a 1.0-day delay between crossing the sector boundary and the actual disconnection, the dispersion of the DEs around the best-fit sector boundary is reasonably close to the dispersion of the spacecraft crossings around the best-fit boundary.

If essentially all DEs have a common physical cause and the DEs observed in comet Halley are representative, modeling efforts should focus on conditions at sector boundaries. Final acceptance of any mechanism requires a detailed simulation that produces DEs.

Development of Analytical Theories for Eccentric Orbits

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In view of the difficulties caused by considerable orbital eccentricities the classical perturbation methods never have been applied to the asteroidal orbits with accuracy level comparable to the theories of major planets. Using extended canonical transformations it is possible to change the independent variable from time t to osculating eccentric anomaly E:

$$(L, G, H, l, g, h; t, F) \rightarrow (L', G', H', l', g', h'; E, F').$$

The resulting equations of motion remain canonical and are expressed in action-angle type Delaunay-like variables. The advantage of new equations is the improved convergence of Hamiltonian, expanded in Fourier series over E instead of t. That accelerates the application of Lie transforms (Deprit, 1969) to the new Hamiltonian F'. In the end we get the expressions of all our variables as functions of osculating eccentric anomaly:

$$L(E), \ldots, h(E); t(E).$$

Considering the immensely complex task of building these transformations a symbolic manipulation software is being developed, that would enable us to work with extremely large series expansions, encountered in various celestial mechanics applications.

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VIDEO OBSERVATIONS OF THE FALL OF THE OCTOBER 9, 1992 PEEKSKILL METEORITE. Peter Brown, Dept. of Physics, Univ. of Western Ontario, London, Ontario, Canada; G.W. Wetherill, DTM, Carnegie Institution of Washington, Washington, DC, USA; Martin Beech, Dept. of Astronomy, Univ. of W. Ontario, Canada; and R.L. Hawkes, Dept. of Physics, Mount Allison University, Sackville, New Brunswick, Canada.

At 2350 UT on October 9, 1992 a "brighter than full moon" fireball was observed over an approximately 10^6 km^2 area of the eastern USA and Canada. Visual observations were reported from locations as distant as Kentucky. The object had a very shallow trajectory and a visible flight time of about 30 seconds. The approximately SW to NE atmospheric flight path began near the W.Virginia-Virginia border in the vicinity of Roanoke, VA, and passed over Maryland and East-central Pennsylvania. A 12.4 Kg fragment, identified as a metamorphosed H-class ordinary chondrite, was recovered in Peekskill, NY, about 75 Km north of New York City.

The event was recorded by a number of professional and amateur video photographers and is the first meteorite fall for which video recordings are available. We have acquired 17 videotapes of observations extending from North Carolina to Ohio and New York State. By use of surveying instruments, we are measuring the positions of foreground objects in the videos, permitting the meteorite's trajectory to be placed in an absolute reference frame. The video data is being analyzed with the intention of extracting the atmospheric trajectory and preatmospheric orbital elements of the meteorite. We are also studying the fireball's fragmentation and tail dynamics, which the video record shows in detail never previously available. The video data show that the meteorite broke into dozens of pieces, of which at least several large fragments survived its terminal break-up. These fragmentation events will be illustrated, together with a map showing the meteorite's flight path. So far, only one of the fragments has been recovered, after it struck a parked car.

CLOSE ENCOUNTERS BETWEEN THE TERRESTRIAL PLANETS AND PLANET-CROSSER ASTEROIDS

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ABSTRACT: In this paper, we asses the importance of close encounters between the terrestrial planets and planet-crossing asteroids. We analyse the potential importance of time-dependence in the flux-rate of asteroids to planet-crosser orbits, concluding that an early heavy bombardment of the planet's surfaces should be less than the present cratering rate, by about 3 orders of magnitude. This result is in complete concordance with previous analysis of the lunar cratering chronology.

ASTEROID TAXONOMY: PROBLEMS AND PROPOSED SOLUTIONS. Thomas H. Burbine (Smithsonian Astrophysical Observatory, Cambridge, MA 02138) and Jeffrey F. Bell (Planetary Geosciences Div., Dept. of Geology & Geophysics, SOEST, Univ. of Hawaii, Honolulu, HI 96822)

For the past twenty years, many different asteroid taxonomies have been developed to classify asteroids according to different sets of observational parameters. The most widely used taxonomy, devised by Tholen [1] [2], classifies approximately 1000 asteroids according to similarities in spectral reflectance from 0.3 to 1.1 µm and visual albedo. No mineralogical information is used in forming the classes, but the same spectral information that is used in classifying asteroids in this wavelength region can give a rough interpretation of surface composition. However to understand the structure of the asteroid belt, these taxonomies are only useful if they are grouping together asteroids with somewhat similar mineralogies and thermal histories. In the last five years, observational data sets (e.g 0.8 to 2.5 µm spectra [3], CCD spectra [4], 3 µm spectra [5]) have been compiled for a much smaller number of asteroids. These "supplementary" data sets allow for much better mineralogical interpretations of asteroids because they allow for the determination of the presence or absence of features such as the 2 µm feature due to pyroxene and/or spinel and a 3 µm feature due to hydrated silicates. Results from the analyses of these data sets include the creation of the K-class [6], identification of anomalous S-asteroids with 2 µm features (believed to be due to spinel) much stronger than their weak to nonexistent 1 µm features [7], and the identification of hydrated M-asteroids [5]. These data sets show that many of the classes contain members with vastly different compositions and/or thermal histories.

One proposed way of using these "supplementary" data sets to classify asteroids would be the use of symbols to indicate the presence or absence of mineralogically diagnostic absorption features. Classes (C, F, M, and T) that contain both members with and without 3 µm features would use the symbol "h" (e.g. Ch) for members with such a feature and the symbol "n" for asteroids without such a feature. The S-class would be broken down into S (olivine-pyroxene mixtures), So (olivine-rich) [8] [9], Sp (pyroxene-rich) [8] [9], and Ss (spinel-rich) subclasses. These new asteroid classes have been placed in a revised Bell superclass table [10] (**Table I**) to try to better show the diversity of the asteroid belt. Also included are two newly proposed classes, J [11] and Z [12]. The mineralogical structure of **Table I** will be constantly changing as the number of asteroids with these "supplementary" observations and the resolution of the resulting spectra both increase. This will lead to the identification of more absorption features and the creation of more asteroid classes and subclasses with better mineralogical interpretations.

Table I

Bell Superclass	Class	Inferred Minerals	Analogous Meteorites	Asteroid Example
Primitive	D	organics	(none)	721 Tabora
	P	organics	(none)	65 Cybele
	Cn+Fn	anhydrous silicates, C	(none)	31 Euphrosyne
	(K)	ol, pyx, carbon	CO and CV chondrites	221 Eos
	Ss	spinel	CO and CV chondrites?	387 Aquitania
	(Z)	organics	(none)	5145 Pholus
Metamorphic	Th	clays, organics	(none)	308 Polyxo
	B+Ch+Fh+G	clays, opaques	altered carb. chondrites	10 Hygiea
	Q	pyx, ol, grey NiFe	H, L, LL chondrites	1862 Apollo
	Mh	clays	altered carb. chondrites	92 Undina
Igneous	V	pyx, plag	eucrites	4 Vesta
	(J)	pyx	diogenites	3155 Lee
	R	ol, pyx	ol-rich achondrites?	349 Dembowska
	S	ol, pyx, red NiFe	lodranites, irons	18 Melpomene
	So	ol, red NiFe	pallasites	354 Eleonora
	Sp	pyx, plag, red NiFe	basaltic achondrites?	1036 Ganymed
	A	ol	brachinites	446 Aeternitas
	Mn	NiFe	irons	16 Psyche
	E	Fe-free pyx	aubrites	64 Angelina

[The superclass of the Tn subclass (e.g. 114 Kassandra) has been interpreted as igneous [13] and metamorphic [14].]

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ON DETERMINATION OF CIRCULAR ASTEROID ORBIT WITH THE USE OF SINGLE CCD OBSERVATION (alpha, delta, alpha-dot, delta-dot, UT)

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As it is known, the modern positional CCD-observation of a celestial body moving on the background of stars gives the coordinates (alpha,delta) and its first derivatives (alpha-dot, delta-dot) for a given moment UT. The accuracy of such CCD-observations is sufficient for determination of reliable circular orbit of the observed celestial body or its initial elliptical orbit on the assumption that obtained observation corresponds to the body's perihelion point. For these orbit determinations we put into practice the Method of Apparent Motion Parameters created at Pulkovo observatory by Dr.A.A. Kiselev and Dr.O.P.Bykov in 1973-80 yrs. This new method may be considered as an extention of Laplace's idea in the problem of initial orbit determination from positional observations. The Laplace and APM-method algorithms were published in [1].

Due to courtesy of Dr.D.Rabinowitz (USA) and Dr.E.Yagudina (Russia) we obtained fine opportunity to apply the results of American CCD-observations of asteroids made in May 1991 on the Spacewatch Telescope of the Steward Observatory on Kitt Peak. These CCD-observations consisted of positions and rates of their changing reffered to a fixed moment UT for 926 asteroids. We calculated the elements of initial orbits practically for each of these objects by the AMP-method using alpha, delta, alpha-dot, delta-dot and UT only. Such informations are likely to be first used for orbit determinations in Astronomy.

Some results of our calculatings for Numbered Minor Planets are presented in a table. At the first line the number of Minor Planet, its theoretical quantatives of the topocentric angular rates and its real orbital elements are given. At the second line there are same data as a result of CCD-observation and our AMP-calculation of circular orbit.

As it follows from presented table our results are very close to real orbits, especially in the case of a real circular moving of the Minor Planet.

On Determination of Circular Asteroid Orbit; O. P. Bykov

NN	alpha-dot	delta-dot	a	e	Omega	i	M+om	1991, May, UT
	(deg. per day)		Orbital elements		(in degrees)			
MP 4060	-0.116	0.050	5.25	0.16	167.6	16.16	28	5.25
CCD 67	- .114	.054	5.34	0.00	174	17.9	42	
MP 2290	-0.208	0.077	2.59	0.24	155.6	11.52	44	5.26
CCD 73	- .228	.081	2.40	0.00	146	9.2	73	
MP 3026	-0.186	0.102	3.03	0.03	215.6	9.64	10	12.25
CCD 299	- .179	.106	3.02	0.00	217.	10.2	9	
MP 1154	-0.190	0.035	3.39	0.07	82.6	4.55	148	13.28
CCD 345	- .210	.040	2.86	0.00	84	4.2	144	
MP 3689	-0.204	0.087	2.88	0.08	201.9	9.34	44	14.40
CCD 518	- .198	.091	2.82	0.00	202	9.0	36	14.40
CCD 533	- .201	.086	2.79	0.00	198	8.1	40	14.41
MP 518	-0.223	0.113	2.53	0.22	203.8	6.74	46	15.20
CCD 578	- .218	.113	2.37	0.00	205	6.7	22	
MP 1910	-0.168	0.089	3.05	0.05	200.7	10.33	18	18.32
CCD 862	- .167	.095	3.15	0.00	205	12.5	21	

We believe that the AMP-method orbits may be used for identifications of observed celestial objects [2]. These orbital computations can be produced in a real time during CCD-observations of Near Earth Objects, for example Artificial Earth Satellites or Asteroids crossing the Earth orbit.

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[2]. Bykov O.P., Komarov V.V. On possibility of an asteroid classification by means of circular orbit obtained with use its single CCD-observation (Poster, presented on this Conference).

ON POSSIBILITY OF AN ASTEROID CLASSIFICATION BY MEANS OF CIRCULAR ORBIT OBTAINED WITH THE USE OF SINGLE CCD OBSERVATION

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In our terminology "a single CCD-observation" of celestial body means the positional observation of its topocentric coordinates (alpha, delta) and its angular rates (alpha-dot, delta-dot) reffered to a fixed moment UT. We have a practice of using such CCD-observations of asteroids for circular initial orbit determinations by means of our AMP-application package. Recently we processed data of CCD-observations and near 900 celestial objects obtained by the Spacewatch Telescope of Steward Observatory on Kitt Peak in May 1991 were classified on asteroid families, streams and trends [1]. We believe that our circular orbits are valid at least within the range of e=0.2. We should distinguish exactly the elliptical or circular movments of celestial bodies if the angular accelerations were available from their CCD-observations.

The brief and compressed results of our classification of asteroids fixed at the "data91.may" by Dr.D.Rabinowitz are presented in a table. It has two entrance (a circular radius r and an inclination i) and shows the number of asteroids having these parameters in observational set considered by us.

r	inclination i (in degrees)													sum
AU	1	3	5	7	9	11	13	15	17	19	21	23	>26	
1.05	1	1	–	–	–	–	–	–	–	–	–	–	–	2
1.3	–	1	3	4	1	1	–	–	–	–	–	–	–	10
1.6	–	–	–	–	5	1	4	1	1	–	–	–	–	12
1.9	–	4	1	2	1	–	–	–	–	–	–	–	–	8
2.0	–	8	7	3	3	1	–	–	–	1	1	–	–	24
2.2	1	26	47	25	9	5	10	4	1	1	1	–	–	130
2.4	2	18	44	33	21	15	18	12	3	2	1	–	–	169
2.6	4	27	27	31	16	18	12	6	4	3	1	1	2	152
2.8	1	25	29	22	20	15	14	2	3	3	2	3	1	140
3.0	3	11	9	22	11	25	12	6	6	2	1	–	–	108
3.2	2	10	8	11	8	11	7	7	2	1	2	1	1	71
3.4	2	–	5	3	2	4	7	1	–	1	1	1	–	27
3.6	–	–	–	1	2	–	–	–	1	1	–	1	2	8
3.8	–	–	2	–	–	1	–	–	1	–	–	–	1	5
4.0	–	–	–	–	–	–	–	1	–	–	–	–	–	1
4.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–
4.6	–	–	–	–	–	–	–	–	–	1	–	–	–	1
4.9	–	–	–	–	1	–	–	–	–	–	–	–	–	1
5.2	–	–	–	–	–	–	–	–	2	–	–	–	–	2
5.5	–	–	–	2	1	1	–	–	–	–	–	–	1	5
6.0	–	–	–	–	–	–	2	–	–	–	1	–	1	4
6.5	–	–	–	–	–	–	–	–	–	–	–	–	1	1
sum	16	131	182	159	101	98	86	40	24	16	11	7	10	881

On Possibility of an Asteroid Classification; O. P. Bykov and V. V. Komarov

We hope to continue the collaboration with our American collegues for the purpose of an application of our results to classify the asteroids directly in real time their CCD-observations. We are ready to carry out the orbital calculations with any CCD-observations of asteroids for the further improvement of Pulkovo AMP-method.

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A Multi-Wavelength Study of the Potentially Meteorite-Producing Comet P/Wilson-Harrington (4015 1979VA)

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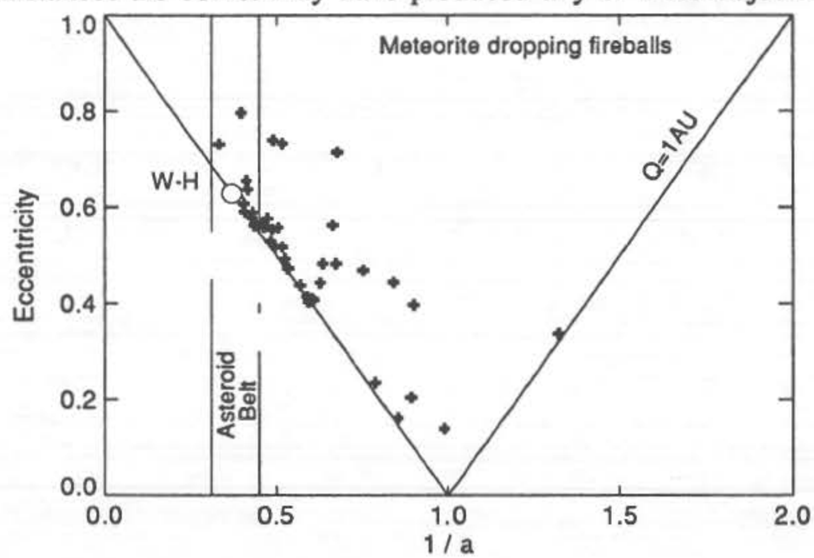
The identification of object 4015, 1979 VA, as Comet P/Wilson-Harrington, P/W-H, (IAUC 5585, 1992) supports the notion that extinct or dormant nuclei of periodic comets can have asteroidal appearance, and that some fraction of the Earth-crossing asteroids have a cometary origin. Furthermore, orbital characteristics make P/W-H particularly interesting even among the comet-asteroid transition objects. It has a low inclination orbit, perihelion just inside 1 AU, and aphelion in the middle of the asteroid belt. This orbit has the potential of delivering meteorites to Earth at relatively low velocities. The figure below plots the orbital eccentricity versus reciprocal semimajor axis of meteorite producing meteoroids (*crosses*) listed by Halliday *et al.*, (J. Roy. Astron. Soc. Can., **83**, 49–80. 1989) and of P/W-H (*open circle*). P/W-H plots close to several meteoroids; we are in the process of doing orbital integrations to determine under what circumstances the comet may have produced any of these objects.



We also obtained time series CCD images (red filter λ_c=7000 Å $\Delta\lambda$=2600 Å) on UT 1992 Dec. 01 and 02 at Lowell Observatory and in the Cousins red bandpass on UT 1992 Dec. 21 and 1993 Jan. 26 at U. of Arizona. These images are being used to determine the rotational characteristics of the comet as well as to search for any detectable coma. Simultaneous reflected (1.26, 1.60, and 2.22 μm) and thermal (10.6 μm) infrared observations were obtained on UT 1992 Dec. 17 at U. of Arizona. Thermal modelling utilizing these observations will provide estimates of the radius and albedo. However, at the time of this writing, the rotational characteristics have not been determined, hence the surface temperature is uncertain. If slow rotation is assumed (standard thermal model) a preliminary estimate of the radius is 1.5 km.

Impacts of Meteoroids Larger Than 1 m into the Earth's Atmosphere.

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Statistical data on meteoroids based on precise photographic and television observations enabled rather detailed classification of bodies in the size range from 0.3 mm to 1 m. This classification is based on non-trivial differences of the atmospheric penetration ranging over air density ratio of 1:1000. Orbits cannot be used to classify bodies of this size as cometary or asteroidal:

population	ρ	σ	characteristic orbit for 0.1 - 1 m size			assumed composition
	g/cm^3	s^2/km^2	a	e	i	
I	3.7	.017	2.4	.68	6°	stony
II	2.0	.041	2.3	.61	5°	carbonaceous
IIIA	0.75	.10	2.4	.82	4°	cometary
IIIAi	0.75	.10	$\approx\infty$	.99	random	cometary
IIIA[C3]	0.75	.10	2.7	.67	random	cometary
IIIB	0.27	.21	3.0	.70	13°	soft cometary

ρ bulk density

σ ablation coefficient

Except satellite tracking of the daylight fireball of Aug 10, 1972, there are available data published on only 13 bodies with initial sizes over 1 m (all below 10 m) photographed within the fireball networks. Data on them all will be given in this paper. Except the Příbram body, all these bodies are only of type II and IIIB. The terminal heights and the heights of maximum light differ by several tens of kilometers for these two types of meteoroids.

Taking advantage of the detailed knowledge in the 0.1 - 1 m size range, we can extrapolate to the 1 - 10 m size range and compare the results with the small number statistics of 14 largest observed meteoroids. We can also compare the total number of all meteoroids with the statistics of the smallest Spacewatch objects. Differences in importance of individual populations (types) of meteoroids are rather large and very much changing with size. Numbers of meteoroids coming to the whole Earth's surface per year for two size intervals follow:

size [m]	I	II	IIIA	IIIB	all	$\bar{\rho}$
0.1 - 1	20000	48000	38000	21000	127000	1.1
1 - 10	190	1290	340	980	2800	0.5

Average bulk density of meteoroids, $\bar{\rho}$, can also be computed by comparing the mass dependence of meteoroid numbers with the size dependence. The change of average bulk density corresponds to relative increase of the cometary populations, namely of the IIIB bodies, with increasing size.

In the following table, the relative percent numbers of the three basic populations demonstrate the large relative deficiency of the stony material among the 10 m size bodies (I $\equiv$ stony, II $\equiv$ carbonaceous, III $\equiv$ cometary). **Majority of the 10 m size meteoroids are cometary bodies with the weakest known structure:**

size	[m]	0.2	0.5	1	2	5	10
I	%	17	15	10	6	3	1
II	%	41	46	48	47	42	30
III	%	42	39	42	47	55	69

Most of the meteoroids in the 1 - 10 m size range are decelerated in the Earth's atmosphere to surface impacting velocity below 4 km/s and regular meteorite falls follow. Only stony bodies with **low initial velocities** (less than 20 km/s) and larger than 8 m can reach the surface with velocities higher than 4 km/s giving rise to an explosive crater.

Meteoroid Properties from Atmospheric Interactions

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When a meteoroid collides with the Earth's atmosphere, most of the mutual kinetic energy is freed in interaction processes. The meteor phenomenon is thus very much dependent on composition and structure of the meteoroid. Even the preheating is a sensitive indicator and the beginning heights of the luminous trajectories can thus be used to classify meteoroids (A, B, C, D groups). The ablation part of the trajectory, which is practically identical with the luminous trajectory, reflects the composition and structure of larger bodies even better. Especially the penetrating abilities of meteoroids (terminal heights), when normalized to the same velocity, to the same mass and to the same inclination of the trajectory to horizon, differs by 1:1000, if expressed in the air densities (groups I, II, IIIA, IIIB). Enormous variety of compositions and structures exceeding our "surface experience" from studying meteorites is evident: meteorites are just samples of the strongest part of interplanetary matter coming to the Earth, which survived the atmospheric entry (groups I and II).

Statistical criteria and studies based on the single body theory enabled distinction of different composition groups in the past. The biggest disadvantage of these procedures was the impossibility of separating the value of ablation coefficient from the bulk density of meteoroids: this was done only statistical way.

Several years ago a new single body model applied directly to individual well-observed meteoroids (multi-station photographs) yielded the possibility of separating the ablation coefficient from the bulk density. This method was used to all available data on PN and EN fireballs with the result of better values of ablation coefficients. At the same time a new phenomenon was revealed: gross-fragmentation. This seemed to be important for about 25% of all observed fireballs, when the time dependences of residuals received from single body solutions were inspected by simple graphical means.

Recently a new model of gross-fragmentation was proposed and checked on several cases, where the fragmentation is directly visible as splitting trails on photographs. The gross-fragmentation model gives the distance flown by the meteoroid along its trajectory, l , as function of time: $l = l(t)$. This distance is also directly derived as l_{obs} from measured values on the multi-station meteor photographs, i.e. from apparent distances along the trail measured for each time mark (velocity is an indirectly derived value and moreover it is the first derivative of the measured distances). Together with height, h, for each time mark, t, the distance, l, is all what is needed to determine the ablation coefficient, the shape-density coefficient, position of the gross-fragmentation point and the amount of fragmented material relatively to the main body mass just by means of the least squares fit of l to l_{obs}.

A computer program for automatic search of gross-fragmentation points was prepared and applied to a sample of 80 records of PN fireballs with precise values of the measured distances and heights. From them 21 proved to be without gross-fragmentation (category NF), 19 with one point of overwhelming amount of fragmentation (category 1F), 11 with many points (at least two) of comparable amount of fragmentation (category MF), 29 with too low accuracy to decide among the above categories. Thus we have a new tool for classification of such meteoroids for which we have very precise data available, i.e. classification according to their sustenance against continuous fragmentation and their ability to be then crushed suddenly in the atmosphere at a point. The classification becomes thus two dimensional in separating at least partly the influence of composition from the influence of structure of the body.

The dynamic pressure ρv^2 (ρ the air density) at the fragmentation points for 1F and MF categories tends to cluster at three separate values: 2.5, 5.3 and 8.0 Mdyn/cm^2 with 40%, 30% and 20% of cases, respectively. The average of the rest is 0.8 Mdyn/cm^2.

The amount of fragmentation for 1F category is typically 60%, which corresponds to breaking the mass into approximately two halves with some accompanying small fragments. The second most important value is between 95% and 99%, which corresponds to almost complete disruption of the body. The distribution of the amount of fragmentation for the MF category is more random than for the 1F category: all values are between 35% and 95%, but a 65% peak is also present. Thus the typical sudden fragmentation for almost half of all fragmented meteoroids is equivalent to stripping away slightly more than half of the mass.

The resulting ablation coefficients from our model differ from the values derived previously by statistical separation of σ from K. Type I: $\sigma = 0.012$ s^2/km^2 (previous statistical value 0.017); type II: 0.037 (0.041); type IIIA: 0.13 (0.10); type IIIB: 0.6 (0.21). The individual bulk densities of meteoroids from our model are about the same as the previous statistical values.

THE BOLOGNA-LECCE FORWARD SCATTER RADAR EXPERIMENT: ACTIVITY AND REFLECTION PROPERTIES OF METEOR SHOWERS IN 1992.

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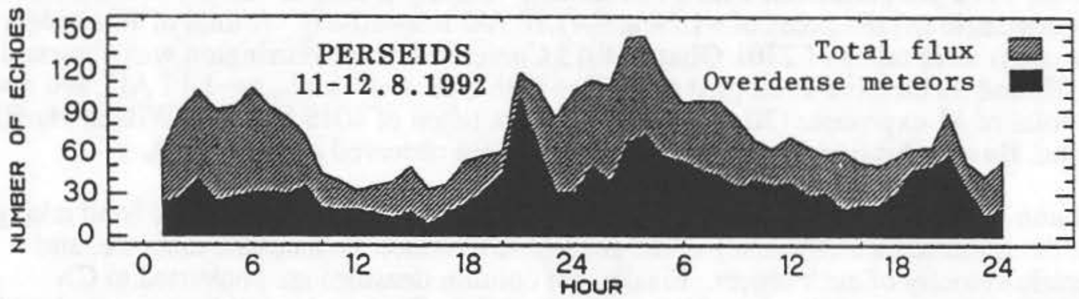
ABSTRACT

Observational results of meteor showers in 1992 - Quadrantids, Lyrids, Perseids and Geminids - as obtained by using a forward scatter (FS) bistatic radar over the Bologna-Lecce baseline (about 750 km) in Italy, are presented in terms of structural aspects and signal amplitude-rate dependence.

Continuous radio monitoring at 42.7MHz of Perseid activity in August 1992 reveals the presence of two outbursts at 20-21 LT in two successive days (11 and 12) mainly due to large particles with long lasting echoes (the first outburst on August 11 with overdense meteor trails being about 80% of the total amount is the most relevant,as shown in Figure). These anomalies appear to be clearly connected to the presence of P/Swift-Tuttle being in the vicinity of its descending node.



The distribution of energy reflected by meteor trails is shown to be correlated with the electron line density **q**, differently for underdense and overdense echoes. It is pointed out that in the cumulative distribution function of meteor trails versus peak signal amplitudes, the number of underdense echoes decreases with the increasing signal more rapidly than predicted **[1, 2]**. By comparing sets of observations and specified theoretical distributions and using the Kolmogorov-Smirnov (K-S) procedure, an exponential model is proposed in order to provide a better fit to trends of underdense meteor trails especially at middle-high levels of received power and for values of $\mathbf{q} \geqslant 10^{13}$ el/m. The present FS observations of meteor showers indicate that the transition region where contributions from both overdense and underdense are important, extends over a wide amplitude range.

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2201 Oljato and 4015 Comet P/Wilson-Harrington: Search for CN (0-0) band Emission

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2201 Oljato is a planet-crossing asteroid which may have evolved from either the main asteroid belt or the reservoir of short-period comets into its current, dynamically unstable, planet crossing orbit. There is both observational evidence of the asteroid's physical properties (McFadden et al., 1993) and dynamical evidence (e.g. Milani et al. 1989) that this asteroid might be an inactive cometary remnant. Asteroid 4015 1979 VA was discovered to be the same object as comet P/Wilson-Harrington 1949 III by Bowell (IAUC 5585). With this knowledge, we made measurements of these two objects to search for CN emission, which is the most easily observed volatile species in comets.

Ground-based observations were made in October 1992 using Lowell Observatory's 1.8m telescope with the Ohio State University CCD spectrograph in order to measure the gas production rate of CN. The CCD spectrograph was configured to give a wavelength range of approximately 3240Å to 6160Å. 2201 Olajto was observed on the nights of 04, 06, 07, 08, and 26 October 1992 pre perihelion with a heliocentric velocity (r-dot) of ~20 km/s and heliocentric (r) and geocentric (Δ) distances of ~1.28 and ~1.10 AU respectively. A total of 16 exposures (20 minutes each) were taken of 2201 Oljato. 4015 Comet P/Wilson-Harrington was observed on 04, 06, 07, and 08 October 1992 post perihelion with r-dot=~11 km/s, r=~1.17 AU, and Δ=~0.76 AU. A total of 11 exposures (20 minutes each) were taken of 4015 Comet P/Wilson-Harrington. Extinction, flux calibration, and solar analog stars were observed on each night.

The column density of CN is calculated from the observed flux at the CN (0-0) band taking into account the fluorescence efficiency at the geocentric distance, heliocentric distance, and heliocentric velocity of each object. Finally, the column densities are converted to CN production rates on the basis of the Haser (1957) model. The results will be compared with production rates observed in comets. Using flux calibrated spectra of 2201 Oljato and 4015 Comet P/Wilson-Harrington, we will divide by a solar analog spectrum to produce relative reflectance spectra. Comparison to previously obtained reflectance spectra will be made.

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ON THE EVOLUTION OF BINARY EARTH–APPROACHING ASTEROIDS

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Radar and lightcurve data suggest that a significant fraction of the Earth–crossing asteroids are contact or nearly–contact binary systems. These binaries have the relative orbit of their components changed by tidal forces when they experience close encounters with the Earth (and the other inner planets). Farinella (1992, Icarus **96**, 284) showed that the time scale for a binary to undergo important orbital energy changes is comparable to its lifetime vs. impact against the planets. We have now refined this estimate, by calculating orbital energy changes for a range of initial conditions by a Monte–Carlo technique and including the effects caused by the hyperbolic (rather than rectilinear) geocentric motion of the binary's center of mass. The results show that the encounters are effective in changing the orbital energy — i.e., the semimajor axis of the system — unless or until the components are very close to each other or in physical contact. Also, the orbital angular momentum of the binary is changed over the same time scale as the energy, implying that the binary's eccentricity evolves at a similar pace as the semimajor axis, the final end–product of this evolution being either escape of the components or a collision between them. This may explain the origin of contact or nearly–contact systems such as 4769 Castalia and 4179 Toutatis.

PLANAR ORBITS ABOUT A TRIAXIAL BODY: APPLICATION TO ASTEROIDAL SATELLITES

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We have studied the dynamical behaviour of a small satellite of a strongly triaxial primary rotating about a principal axis of inertia, restricting ourselves to the planar case (satellite orbits lying in the "equatorial" symmetry plane of the primary). Since we were mainly interested in applying the results to the dynamics of (natural and artificial) asteroidal satellites, we have studied in detail the case of a triaxial ellipsoidal primary, with axial ratios $\sqrt{2} : 1 : 1/\sqrt{2}$ and rotation periods ranging from 5 to 40 hours. We have employed the classical method of Poincaré's surfaces of section to display the results of numerical integration experiments, showing in particular how the triaxial shape of the primary "perturbs" the dynamics of the Kepler problem seen in a rotating reference frame where the primary is fixed. We find that a large chaotic zone appears near the $1 : 1$ resonance between the rotation period of the primary and the orbital period of the satellite. Another small chaotic zone appears for retrograde orbits passing close to the primary and corresponding to initial velocities close to the escape velocity. We discuss the possibility of putting an artificial satellite in orbit about a triaxial asteroid, providing examples of orbits close to the asteroid but almost unaffected by its (*a priori* unknown) mass distribution.

ON THE SHAPE OF COMETARY ENVELOPES

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ABSTRACT

It is shown by means of a modified Newton's formula that the outline of cometary heads (the cometary envelope) is close to a catenary.

NOTE ON THE SPLITTING OF COMET HALLEY

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Abstract:

In combination with our observation about the splitting of Comet Hilly in March 1986, the events involving the sharp, straight feature in the antisolar direction observed in the head of Comet Halley in 1910 (such as those occurred on May 14, May 25, May 31 and June 2) are rediscussed. The analysis leads to the following scenario: When Comet Halley explodes and splits, a fragment jettisoned or thrown off from the nucleus will, after moving to the direction of its tail, develop to a mini-comet. Although not well developed and permanent, it has its own plasma tail and, sometimes, dust tail. If we assume as the definition (Bobrovnikoff's) of a secondary nucleus its activity in the formation of jets and emission fans, then the fragment should be considered as real secondary nucleus.

It seems the current idea of tailward jet suggested by Sekanina and Larson is a wrong explanation to the plasma tail of mini-comet and thereupon the rotation period of 52-53 hr for Comet Halley is doubtful.

Photometry and Polarimetry of Comet Shoemaker–Levy 1991 a1

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The photoelectric photometry and polarimetry of comet Shoemaker–Levy 1991 a1 was conducted with the 1–m telescope at Sanglok Observatory, Tadjikistan during 1992 May 27– Aug 2. An estimate of production rates for species CN, C_3, and C_2 and the dust particles have been made. The degree of polarization at the phase angles $60^o - 70^o$ was somewhat smaller than the corresponding polarization of P/Halley.

Photoelectric Photometry of the Asteroid 2078 Nanking

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The asteroid 2078 Nanking was observed with the 1-m telescope at Sanglok Observatory, Tadjikistan. The rotation period was determined to be 6.463 hours. The absolute magnitude V(1.0) was found to be 13.2 mag, the lightcurve amplitude Δ V = 0.8 mag, and the colors U-B, B-V, V-R are 0.22 mag, 0.85 mag and 0.59 mag, respectively. Assuming that the geometric albedo $\rho_v = 0.12$, the size of Nanking is 8.8×6.1 km.

OBSERVATIONS OF (4179) TOUTATIS IN AUGUST 1992–MARCH 1993 AT THE CRIMEAN ASTROPHYSICAL OBSERVATORY. Chernykh N. S.[1], Prokof'eva V. V.[1], Chernykh L. I.[2], Karachkina L. G.[2], Rumyantsev V. V.[2], Zhuravleva L. V.[2], and Tarashchuk V. P.[3], [1]Crimean Astrophysical Observatory, Crimea, Ukraine, [2]Institute for Theoretical Astronomy, St. Petersburg, Russia, [3]Kiev University Observatory, Ukraine.

The results of the astrometrical and photometrical observations of (4179) Toutatis at the Crimean Astrophysical Observatory obtained in the time of the approach of the asteroid are presented and discussed.

Forty-nine astrometrical positions were determined with the Zeiss double 40-cm astrograph. Measured coordinates of the asteroid are referred to the PPM Catalogue system. The precision of positions is about 0.5 arcsec. The observations show that the orbital elements of Toutatis from MPC 21085 need very little correction.

The photometrical observations of Toutatis in UBVRI system were carried out using a high-sensitivity television complex attached to the 0.5-m meniscus telescope. The observed brightness of the asteroid was in the range of 9–19 magnitudes. The exposure time changed from 6 sec up to 6 min. The color variations during the night observations were recorded. The obtained photometrical data may be used for determination of the rotation period.

PHASE DEPENDENCIES OF COMETARY LIGHT CURVES

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The analysis of phase dependencies of light curves of nine comets was made. Each light curve had a mathematical model based on regression analysis. The model input characteristics are logr (r - heliocentric distance) and α - the phase angle. For determination of the photometric parameters of light curves the three parametrical formula was used

$$m_{\Delta} = H_y + 2.5 \log r + \beta\alpha$$

The F-criterion was used to test the hypothesis importance with 0.95 reliability. Also the value $F=(S-S')\cdot(N-3)/S$ was determined (here S' and S are sums of discrepancies of conditional equations under $\beta=0$ or $\beta\neq0$, N - numbers of equations. The F-distribution tables under 0.95 reliability gave values $f_{0.95}$. With $F>f_{0.95}$ the hypothesis $\beta\neq0$ was taken. In the contrary case $\beta=0$ was taken.

The obtained results are given in the Table.

Comets	β	α	N
Tago-Sato-Kosaka (1969 IX)	0	11–19	53
Abe (1970 XV)	0.0190±0.006	23–53	70
Enke (1980 XI)	-0.0014±0.003	38–130	162
Churyumov-Gerasimenko (1982 VIII)	0.0031±0.004	12–38	333
Tempel 1 (1983 XI)	0	11–43	238
Cernis (1983 XII)	0.06 ±0.01	7–18	236
Crommellin (1984 IV)	-0.09 ±0.03	41–69	283
Halley (1986 III)	0	0–67	4140
Borrelly (1987 XXXIII)	0	28–42	505

The division of comets depending on the phase coefficient β of the light curve into two groups was suggested.

For *group I* $\beta>0$. Comets - Abe (1970 XV), P/Churyumov-Gerasimenko (1982 VIII), Cernis (1983 XII). This group is characterized by great retardation of maximum brightness after perihelion (the maximal retardation of 40-45 days takes place for the comet P/Churyumov-Gerasimenko (1982 VIII)).

For *group II* $\beta<0$. Comets - Crommellin (1984 IV), Enke (1980 XI). The brightness maximum of light curve coincides with the momentum of the comet passage through the perihelion.

PHYSICAL CONDITIONS IN NEUTRAL GAS ATMOSPHERE OF P/HALLEY (1986 III) ON THE BASIS OF SPECTRAL OBSERVATIONS

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The comet P/Halley was observed by K.I.Churyumov on the 1-m Zeiss reflector with the UAGS spectrograph and electrooptic camera in Assy (near Alma-Ata). During three nights of observations May, 8-10, 1986 40 spectra of the comet and star standards in the spectral range λλ 370-630 nm were obtained. The detailed analysis of the physical conditions in the comet's head spectra with position angles 0°, 30°, 60°, 90°, 120°, 150°, 180°, 210°, 240°, 270°, 300°, 330° respectively to the radius-vector of the comet has been made. In accordance with the spectra measurements on the micro photometer distribution of the surface brightness perpendicular to dispersion in emissions CN (3883 Å), C_3 (4050 Å), C_2 (4737 Å) and C_2 (5165 Å) were plotted. In accordance with the luminosity of each of the lines the nucleus gas production for the molecules in question by Haser's model was determined. In order to determine the outflow velocity of the gas component V and the lifetime of the molecules τ monochromatic profiles were processed by Shul'man's model. The two values vary substantially with changes of the cometocentric distance ρ. The lifetime of the C_3 molecules decrease monotonously with the growth of ρ. For CN and C_2 molecules first τ increases, and then after the maximum has been reached decreases at the distance 10^4-$4\cdot10^4$ km. The outflow velocity V for all types of molecules behave similarly: it increases with ρ up to the maximal, after that it does not practically change. It appeared that it can be approximated with great accuracy by the dependence,

$$V^2 = V_\infty^2 - \frac{2g_o}{\alpha}\cdot e^{-\alpha\rho},$$

where g_0 - the radial acceleration of the molecules near the nucleus under some additional force, α is the scale coefficient. The values of the determined physical parameters are given in the Table.

Species	Date	V, m/s	τ, 10^4 s	V_o, m/s	V_∞, m/s	g_o, 10^{-3} m/s^2	α, 10^{-8} m^{-1}
C_2 5165	8	460	7.9	51	580	5.7	3.4
	9	480	7.0	200	570	5.3	3.7
	10	510	7.7	61	610	6.6	3.6
C_2 4737	8	400	7.2	21	540	4.5	3.1
	9	400	6.6	90	570	4.1	2.6
	10	380	6.9	112	560	4.0	2.7
C_3	8	110	12.9	12	170	0.7	4.9
	9	110	16.8	41	170	0.6	4.9
CN	8	290	6.8	80	400	0.4	5.2
	9	180	14.4	21	230	1.2	4.8

REGOLITH OPTICAL ALTERATION EXPERIMENTS ON THE MURCHISON CARBONACEOUS CHONDRITE: SPECTRAL EFFECTS; Beth E. Clark, Fraser P. Fanale and Mark S. Robinson, Planetary Geosciences, University of Hawaii at Manoa, 2525 Correa Road, Honolulu, Hawaii, 96822

Introduction: When using telescopic and remote sensing observations to derive mineralogical information, the importance of "space weathering" to the optical surfaces of target objects should be considered. As on the moon, the optical properties of the regolith may differ from those of the bedrock, leading to erroneous interpretation. We present the results of an experimental simulation of the melting and recrystallization that may occur to the surface of a carbonaceous chondrite meteorite parent body due to impact heating or other processes. We have performed similar experiments on ordinary chondrite meteorites to specifically study the changes in spectral reflectance properties. For this paper we report the mineralogical changes that occur from simulated regolith alteration on Murchison, and we discuss the resulting changes in spectral properties.

Method: The meteorite sample was ground to powder with grain sizes of <180 and <90 microns. The reflectance spectra of these powders were measured from 0.3 to 2.5 microns. The sample was then melted and quenched in a fusion furnace at a temp. of 1700° C and reground to a powder for measurement of its reflectance spectrum. Optical microscopy and electron microprobe analyses were performed on the samples before and after alteration.

Results: The spectral effects of simulated regolith alteration by melting and comminution are significant. Following alteration the fused sample shows a dramatic increase in reflectance of about 40% as well as a band center wavelength shift of about 0.25 microns, from 0.75 to 1.0 microns. This would indicate a correspondingly significant change to the mineralogy of the altered sample. In fact, photomicrographs of polished grain mounts of Murchison, before and after alteration, do indeed indicate a mineralogical change. *Silicate Alteration:* Olivines present in chondrules have varying low-fayalite compositions (0-1) in the before sample, whereas in the after sample olivines have much higher fayalitic compositions (~20). The altered sample also shows skeletal quench textures in olivines and an increase in average crystal size. Whereas matrix composes roughly 80% of the unaltered Murchison, there is a complete absence of fine-grained dark matrix material in the altered sample. *Metal-troilite Alteration:* In addition, metallic components are about a factor of 3 times more abundant in the altered sample (8.3%) than they are in the unaltered sample (3.0%). The metal and troilite phases which occurred as separate grains in the unaltered sample are now intergrown and more numerous in the altered sample.

Conclusions: The simultaneous increase in fayalitic olivine and Fe,Ni and troilite in the altered sample indicates that destruction and reduction of the iron-rich matrix must have occurred. Carbon reduction of the hydrated silicates composing 80% of Murchison's matrix is thus responsible for the wavelength shift of the mafic absorption band. Whereas in the unaltered sample the band position at 0.75 microns indicates lower $Fe^{2+}/(Fe^{2+} + Fe^{3+})$, the after alteration band position at 1.0 microns indicates higher $Fe^{2+}/(Fe^{2+} + Fe^{3+})$, or lower total Fe^{3+}. Destruction and recrystallization of the dark matrix material is also likely to be the dominant cause of the increase in reflectance seen in the altered sample. Finally, it is interesting to note that the normalized spectral reflectance curves of ordinary and carbonaceous chondrites are quite similar after alteration, but are quite dissimilar before alteration.

We are in the process of performing similar experiments with other petrologic types of the carbonaceous chondrites. Changes in spectral properties will be used to analyze spectral variations which possibly occur due to surface processses among the low-albedo C, B, G, and F-type asteroids as well as the moons of Mars, Phobos and Deimos, and the irregular satellites of Jupiter.

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Modeling the Variability of Gas Production From Comet Halley

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We obtained spatially-resolved, moderate-resolution spectra of comet Halley from McDonald Observatory during 1985 and 1986 in order to study the distribution of gas in the coma. The data pre-perihelion were obtained with an Intensified Dissector Scanner (IDS) while the post-perihelion data were obtained with a long-slit CCD spectrograph (LCS). From these spectra, we derived the distribution of CN, C_3, and C_2 in the coma. The pre-perihelion data showed a reasonable amount of symmetry and constancy but the profiles in the post-perihelion data are quite asymmetric and variable. This is consistent with the range of activity seen by others. We used a gridding version of the vectorial model (Festou, *Astron. and Astrophys.* **95**, 69, 1981) to derive fits to the pre-perihelion data assuming that the activity was constant during timescales of days. We then used the derived lifetimes to try to model the detailed shapes of a series of profiles from March 20–24, 1986. For these models, we used the vectorial model and included variable production rates. We were able to produce model results which are quite convincing fits of the profiles. From this, we derive a "light curve" of gas production for each model. We will present these light curves and compare them with the observed photometrically derived light curve of Millis and Schleicher (*Nature* **324**, 646, 1986). We show that we can derive a qualitatively similar light curve with a lag in the production which is a function of the molecule under study and the aperture size. These results demonstrate that a time series of gas distribution profiles may be inverted to produce a light curve which matches well with direct photometry.

High Resolution Spectroscopy of CN in Comet Brorsen-Metcalf (1989 X)

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We obtained a high resolution spectrum of the CN B-X $\Delta v = 0$ band in Comet Brorsen-Metcalf (1989 X) using the coudé spectrograph of the McDonald Observatory 2.7m telescope on 25 August 1989. At that time, the comet was at $R = 0.64\,\mathrm{AU}$, $\Delta = 0.77\,\mathrm{AU}$, with $\dot{R} = -26.1\,\mathrm{km\,s^{-1}}$ and $\dot{\Delta} = 27.6\,\mathrm{km\,s^{-1}}$. The comet was approximately centered in a slit which was 61.5 arcsec long. The resolving power of 60,000 allowed the individual rotational lines to be resolved easily. These data will be used to test fluorescence models of cometary CN emission by detailed comparison of the data with theoretical calculations. We will also look for spatial variations of the spectrum which may be diagnostic of the Greenstein Effect, or of collisional effects in the inner coma. The signal/noise of the data is not high enough to measure the ^{13}CN lines reliably.

Cometary dust simulation in the laboratory: experimental results

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Many astronomical observations are today available on a wide variety of comets which have allowed to characterize better both physical and chemical properties of this class of "primordial" objects. In addition, space missions towards P/Halley, in 1986, and P/Grigg-Skjellerup, in 1992, have provided a wealth of data obtained by "in situ" measurements. Nevertheless, a large number of problems concerning the actual nature of comets remain open and need further investigation to be better understood. In this context, the laboratory simulation of processes active in cometary environment can provide valuable information to be compared with astronomical data. An important subject to be clarified is the relation between the present and the original composition of comets. In particular, can the comets be considered the reservoir of unaltered interstellar dust ? The systematic study of morphological, structural, and chemical properties of "analogue" materials either produced in the laboratory or originating from terrestrial samples, can complement astronomical observations on both comets and interstellar medium to try to answer the previous question. From several years, our group is involved in the field of laboratory simulation of cosmic dust. In the present paper, recent laboratory data, obtained on both carbonaceous and silicatic micron and/or submicron grains, are applyed to discuss some hypotheses that have been formulated about the chemical and structural composition of these components.

Radio observations of anisotropic outgassing in comets.

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We observed comets P/Halley during one year, Austin (1990 V) from mid-February to mid-June 1990, Levy (1990 XX) from mid-June to the end of September 1990 and P/Swift-Tuttle 1992t from mid-October 1992 to the 12th of January 1993 at the Nançay Radio Telescope.

Often, the OH radical 18-cm lines observed at Nançay were blueshifted with respect to the nucleus velocity. Redshifts were also observed a few times. Greenstein effect can cause line asymmetry. After modelling and substracting this effect, a significant line shift of -0.16 km.s^{-1} is still found for P/Halley. In comets Austin and Levy, similar values were obtained. Comet P/Swift-Tuttle produced a much stronger systematic blueshift of 0.5 to 1.0 km.s^{-1}.

The IRAM 30-m Telescope observed the millimetre (1 to 3 mm) rotational lines of several molecules in these comets: HCN in all four comets, H_2CO, CH_3OH and H_2S in comets Austin, Levy and P/Swift-Tuttle. Blueshifts were also observed, in close agreement with the residual line shifts of the OH line. This shows that the Greenstein effect in the OH lines is correctly understood, and that no other secondary effect is affecting this dissociation product.

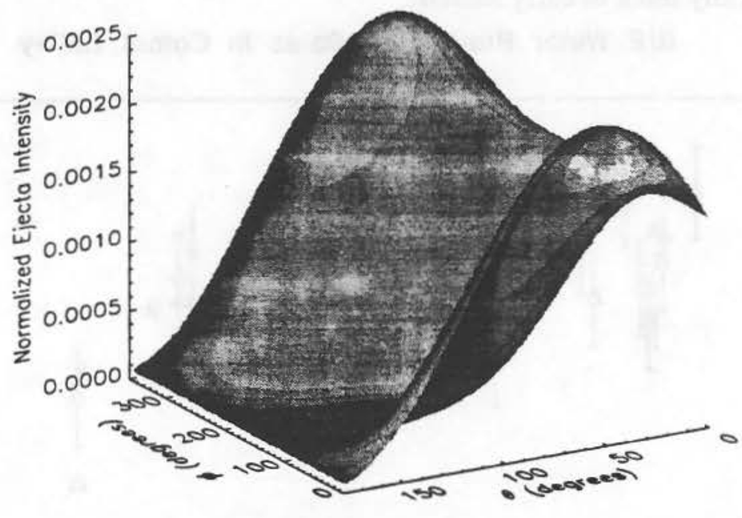
The case for P/Swift-Tuttle is peculiarly interesting, because of the high values of the line shifts and of the high signal-to-noise ratios, which allows a good determination of the unusual asymmetric line shape. This latter is probably related to the strong dust jets observed in optical images.

All these blueshifts are the line-of-sight projections of the gas bulk velocities, and reflect the presence of asymmetries in the gas expansion responsable for the non-gravitational forces acting onto the nucleus of these comets. Since all observations were made at acute phase angle, this corresponds to an excess outgassing towards the Sun. These observations, combined with the non-gravitational parameters A_1 and A_2, should allow us to constrain the nuclei masses.

INTERACTION OF INTERPLANETARY IMPACTORS WITH PLANETARY RINGS AND SATELLITES; Joshua E. Colwell and Larry W. Esposito, Laboratory for Atmospheric and Space Physics, University of Colorado, Box 392, Boulder, CO 80309

Impacts by micrometeoroids and comets are driving forces in the evolution of planetary ring and satellite systems. Small moons discovered by Voyager around each of the giant planets are subject to catastrophic disruption by cometary impact. The disruption of these moons has been proposed as a source for the ring material around Uranus and Neptune [1]. The fate of the moons hinges on the population of comets in the outer solar system and their orbital distribution. "Planet-family" comets on low eccentricity orbits are accelerated to high impact speeds by the planet's gravitational field, and comets as small as 1 km in diameter can destroy some of the observed outer planet satellites. We have modeled the successive destruction of moons and their debris by catastrophic fragmentation from comet impacts. Our results suggest that many of the observed satellites cannot be primordial with an assumed population of planet-family comets in the outer solar system. Future work on the dynamical evolution of comets from the Kuiper belt to the outer planets is necessary to reduce the uncertainties in the moon lifetimes.

The debris from disrupted moons produces planetary rings and moonlet belts which are in turn eroded by micrometeoroid bombardment [2-5]. We have modeled the distribution of ejecta from moons orbiting the giant planets due to micrometeoroid bombardment. Micron-sized ejecta are subject to destructive processes such as radiation and plasma drag on short timescales. The optical depth and spatial distribution of planetary dust rings thus depend critically on the source function by micrometeoroid bombardment.



Micrometeoroid ejecta intensities for "planet-family" impactors at Uranus.

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IUE Observations of H Lyman-alpha in Comet P/Halley

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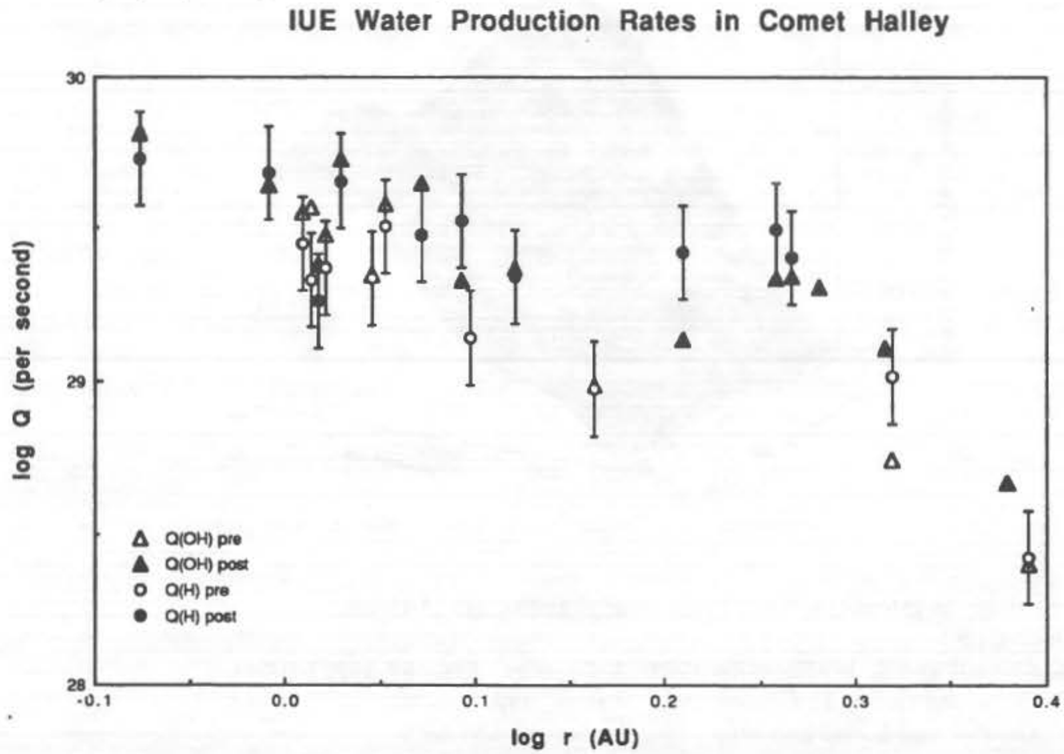
Comet P/Halley was observed throughout the 1985-1986 apparition by the International Ultraviolet Observer (IUE) satellite. Although IUE observations of other species are routinely analyzed, H Lyman-alpha observations have generally not been because the complexities introduced by the small region of the coma sampled by IUE compared with entire H coma and the fact that this inner region of the H coma is often optically thick to solar Lyman-alpha photons. We present here the results of the analysis of the IUE hydrogen Lyman-alpha observations using the combination of the hybrid gasdynamic/Monte Carlo model and a spherical Lyman-alpha radiative transfer model (Combi and Feldman, 1992, *Icarus* **97**, 260). The observations include those with the large aperture both centered on the position of the nucleus and offset by 40-64 arc seconds. We have compared the water production rates inferred from the H Lyman-alpha observations with those extracted from the IUE observations of OH (Feldman, et al. 1987, *Astron. Astr.* **187**, 325) and analyzed with self-consistent hybrid OH models (Combi, Bos and Smyth 1993, *Astrophys. J.* **408**, in press). The agreement is quite good even when the coma was highly optically thick in early March.



Water production rates determined by self-consistent analyses of H (circles) and OH (triangles) from IUE observations of comet P/Halley. The filled symbols are postperihelion and the open symbols are preperihelion. The error bars are fairly uniform owing to the larger relative importance of the optical depth uncertainty at small heliocentric distance but the larger relative uncertainty of the geocoronal sky background subtraction at large heliocentric distance.

H_2O^+ JETS IN THE COMA OF COMET HALLEY?

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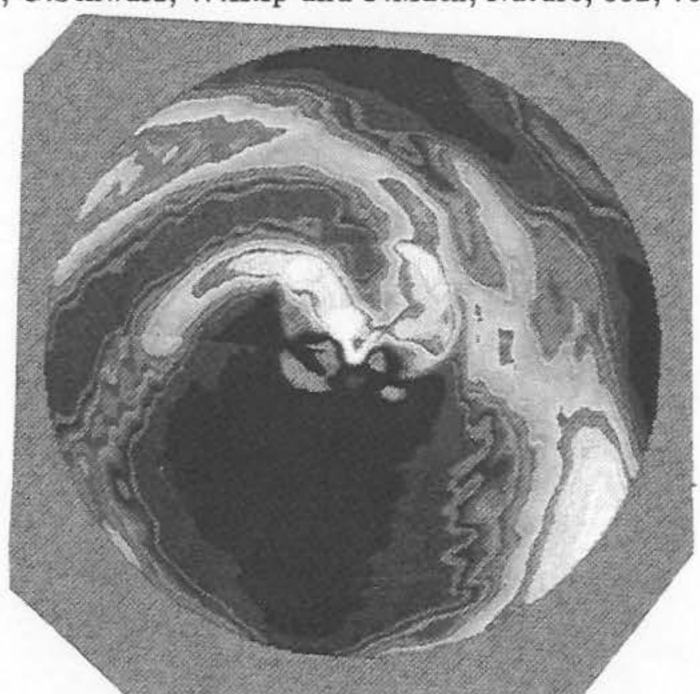
Previous investigations applying the "ring masking" technique to CCD - images obtained at the South African Observatory in the period March 13-18, 1986 led to the detection of CN, C_2, C_3 and ([OI] + NH_2) jet features in the coma of Comet Halley (1). In complement to these results we report here the probable detection of jet features in water ion emission at 6193 Åwhich may be used as a tracer for the time - dependent anisotropic emission profile of the water vapour from the cometary nucleus.
We compared the South Africa images with images taken at Catalina Observatory with the same filter on January 20 and March 7/8/24, 1986 in order to exclude instrumental errors. A clear H_2O^+ jet on March 7 in the Arizona images has no continuum counterpart.
Because of the narrow bandwidth of the filter (6193 $\pm$ 21 Å) other significant molecular contaminations could be excluded.
In this paper we will discuss the mechanism which could lead to H_2O^+ - jets formation and compare the results with other H_2O^+ - distribution measurements in the Coma of Comet Halley.

(1) C.B.Cosmovici, G.Schwarz, W.H.Ip and P.Mack, Nature, 332, 705, 1988



CCD Image of H_2O^+ Jets. March 14, 1986, 03:28 U.T.

THE DUST ENVIRONMENT OF COMET LEVY 1990c

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We analyse wide field images of the dust perspectical antitail of Comet Levy 1990c taken on February 1991 with the UK Schmidt Telescope Unit. In this poster we discuss the results provided by the inverse dust tail model, which allows to obtain information on the dust ejection velocity, loss rate and size distribution for the time interval -180 < t < +100 days (related to perihelion) and diameters bewteen 2 micron and 2 mm. The dust velocity increases from 30+-10 m/s at t = -180+-20 to 100 m/s at perihelion, and then decreases to 30+-10 m/s at t = +100. The mass loss rate reaches a broad maximum of about 3 10**7 g/s ten days before perihelion. The power index of the time-averaged size distribution is -3.2 +- 0.1.

THE NECK-LINE OF COMET OKAZAKI-LEVY-RUDENKO 1989r

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A wide field image of the dust tail of Comet Okazaki-Levy-Rudenko 1989r was taken with the UK Schmidt Telescope Unit by A. Savage and C.A. Frost on Decemebre 30.50, 1989. In this poster we interpret the complex features recorded by the plate in terms of the Neck-Line model. Further, the inverse dust tail model allows to obtain information on the dust environment of this comet during four months before the observations.

A general Physicochemical model of the inner coma of active comets: 1. Gas and dust outflow in the case of dominantly distributed gas and dust production

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SUMMARY

A new physicochemical model of the inner coma of active comets has been developed. The main goal of the model is to systematically explore which gas and dust production schemes are compatible with the very incomplete experimental information available on the inner coma and nucleus of comets.

The method consists in computing the outflow (under solar illumination) of a multiphase gas and dust mixture with full allowance for interphase transfers, between two reference surfaces. The outer surface is the closest surface to the nucleus where significant information on the coma composition is available: any given solution is considered acceptable or unacceptable by reference to this available information. At the inner surface (the nucleus surface), the boundary conditions are fully free, i.e., the size of the active area, the ratio between solid mass emission rate and gas mass emission rate, and the properties of the solids emitted (mass spectrum, relative volatile-to-refractory content of the solids, mineralic composition of the refractory part) can be prescribed freely. In other words, at the nucleus: (1) the gas phase composition and mass flux, and (2) the solid grains total mass flux, mass spectrum, and internal grain chemical can differ radically from the observed quantities at the outer surface (only the total flux of each chemical is preserved). The driving process which introduces these differences is solar illumination (visible and UV).

Great care is taken to make use only state-of-the art gasdynamic methods reliably used by many groups to model laboratory and industrial multiphase flows of condensible vapors, and to exclude the numerous unphysical assumptions that weaken many existing coma models ([1]), so that the solutions obtained could also (regardsless of cost) be tested by simulation experiments, and by appropriate in-situ instrumentation.

As an example of the model capabilities, we present one solution adjusted to P/Halley flyby gas and dust data, in which *95 % of the gas and 95 % of the measured dust distribution* are produced between 0 and 500 Km from nucleus surface by large (cm size) fragments of the nucleus surface (i.e., made-up of ice, silicate and carbonaceous material) emitted from very small areas of the nucleus and accelerated away by the 5 % of the gas which issues directly from these areas. We show that solutions of this kind are free from the objections which can be addressed to the the classical nucleus production models, thus are likely to represent the structure of the inner coma of active comets much more realistically than classical coma models. We conclude that the design of future in-situ inner coma probing instrumentation on board of a rendez-vous spacecraft should not be based on predictions from such classical models.

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A general Physicochemical model of the inner coma of active comets: 2. Gas Phase Van der Waals and covalent chemistry.

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SUMMARY

A new physicochemical model of the inner coma of active comets has been developed ([1]). As one example of the model capabilities, the composition of the inner coma of P/Halley at the time of the flyby missions has been computed, assuming that *95 % of the gas and 95 % of the measured dust distribution* are produced between 0 and 500 Km from nucleus surface by large (cm size) fragments of the nucleus surface (i.e., made-up of ice, silicate and carbonaceous material) emitted from very small areas of the nucleus and accelerated away by the 5 % of the gas which issues directly from these areas ([1]).

We investigate here the consequences of these assumptions on the chemical composition of the inner coma (neutrals and charged constituents). For that purpose, we have incorporated in the model:

(a) the network of classsical (or "covalent") photochemical reactions produced by UV illumination of a water vapor atmosphere ([2]);

(b) the network of homogeneous recondensation reactions (or "Van der Waals reactions") which develop in any expansion cooled water atmosphere ([2,3]);

(c) the network of water cluster charging reactions which was shown precedingly ([4]) to result in the dominance of positively and of negatively charged heavy water clusters in the inner coma under "classical" assumptions with respect to gas and dust production (100 % production at the surface of the nucleus).

The net outcome of this gas phase chemistry under the present assumptions exhibits a number of differences with the previous solutions: this is mainly due to the different water supersaturation radial profile resulting from the radial distribution of water vapor production, and to the increased UV transparency of the inner coma also due to this effect. These results reinforce the conclusion already arrived at in ([1]) that the design of future in-situ inner coma probing instrumentation on board of a rendez-vous spacecraft should not be based on predictions from "classical" coma models which were developed long before the Halley flyby Era, and did not address specifically to the chemistry of the innermost coma.

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[2]Crifo, J.F., Cometary gas-phase chemistry taking into account homogeneous and ion-induced water recondensation. ApJ 391,336-352.(1992)

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Molecular abundances in comets

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The molecular composition of cometary volatiles is a basic information on the nature of comets and an important clue to their formation mechanisms. For a long time, the only informations on this composition were coming from the signatures of dissociation products in the visible spectrum. It is only recently that we obtained direct identifications of cometary volatiles through *in situ* exploration as well as from remote sensing at UV, IR and radio wavelengths.

We will present an inventory of known cometary volatiles, with a critical review of the evaluation of their abundances. Water prevails, but CO compounds (CO and CO_2) and CHO compounds (CH_3OH, H_2CO) are relatively abundant. No hydrocarbon has yet been definitely identified. It has often been argued that nitrogen is deficient, but this may be due to the unability of cometary nuclei to retain N_2.

Some abundance determinations are still controversial, especially for species (like H_2CO) which may come either from the nucleus, or from a distributed source (grains), or from both. Important variations from comet to comet may be present.

There are still many unidentified compounds, some of them possibly relatively abundant. The progenitors of the C_2 and C_3 radicals are still to be found. The important infrared emission around 3.4 μm cannot be fully explained by CH_3OH and H_2CO, and other CHO species may be present in abundance. Aromatic compounds are revealed by the presence of a noticeable feature at 3.28 μm.

It must be pointed out that this inventory of abundances pertains to volatiles sublimed at about 1 AU from the Sun. Because of fractionation processes, it may greatly differ from the true volatile abundances within the nucleus. The activity of comets at large heliocentric distances testifies to the importance of highly volatile species.

All cometary volatiles are important gas and condensed phase interstellar constituants. A detailed comparison of cometary and interstellar abundances is not easy, however, because our knowledge of gas-phase interstellar molecules is biased towards polar species, and the abundances of solid-phase interstellar species is very poorly known. It results that one cannot yet conclude whether comets formed form unaltered insterstellar matter.

COMET AND ASTEROID ASTROMETRY WITH THE NORDIC OPTICAL TELESCOPE (NOT): A PROGRESS REPORT. O. C. Dahl and K. Aksnes, Institute of Theoretical Astrophysics, University of Oslo, Norway.

A program for astrometric charged-couple device (CCD) observations of comets and asteroids has been initiated with the 2.5-m Nordic Optical Telescope on La Palma. This paper reports on 92 observations of 2 comets and 23 asteroids and assesses the astrometric accuracy of the observations.

An Orbital Evolution Study of the Hilda Asteroids

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The orbital evolution of the Hilda asteroids, which is a group of asteroids situated in the 3:2 mean motion resonance with Jupiter at 3.97 AU, have been studied. Numerical integrations of all 52 numbered Hildas (as of January 1992) have been performed. The 15:th order RADAU integrator (Everhart, 1985) and a Jupiter to Neptune solar system modell have been used in the 600 000 years forward and backward integration.

All 52 Hildas have very stable orbital evolution and no indication at all of chaotic evolution is found. All Hildas except three are protected againt close encounters with Jupiter by the libration of the critical argument around 0°. The best protected asteroid, 3415 Danby, never comes closer to Jupiter than 1.94 AU.

The three asteroids which have a circulating critical argument (334 Chicago, 1256 Normannia, 4196 Shuya) avoid close encounters with Jupiter because they have lower eccentricity and the apsidal lines of Jupiter and the asteroid are always aligned when the asteroid have its largest eccentricity. Eventhough, 334 Chicago comes as close as 1.06 AU from Jupiter, it do not come close enough to have a chaotic evolution.

The result shows that the Hilda asteroids can reside for more than 10^6 years in the 3:2 resonance, probably they are stable for much longer spans of time because none of the Hildas show any sign of chaotic behavior.

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CCD Photometry of Hilda Asteroids.

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The Hilda asteroids are an isolated group of asteroids in the outer parts of the asteroid belt, they are situated in the stable 3:2 resonance with Jupiter at 3.97 AU. We are performing an observational study of the Hilda asteroids including both photometry and spectroscopy.

New results on the photometric part of the study will be presented.

ASTEROID COLLISION STUDIES: RESULTS USING SCALING LAWS FROM HYDROCODE MODELS AND DIMENSIONAL ANALYSIS; D.R. Davis (Planetary Science Institute), E.V. Ryan (Planetary Science Institute), P. Farinella (Universita de Pisa)

Recent development of a numerical hydrocode including finite strength effects (Melosh *et al.*, 1992) and the application of this code to problems of the collisional fragmentation of asteroids has produced a new scaling law for the specific energy needed to break up asteroids of different sizes. This work predicts a more rapid weakening of asteroids with size in the strength regime than did the earlier scaling theory of Housen and Holsapple (1990) which was based on dimensional analysis but employed many of the same assumptions as did the hydrocode algorithm. In Fig. 1, we present results from these two approaches for basaltic targets. The dimensional analysis based law scales as $D^{-1/4}$, while that based on the hydrocode calculations varies as $D^{-0.4}$, which predicts significantly weaker (i.e., less collisional energy is required to fracture the body) asteroids in the intermediate size range.

One important test for a scaling law for collisional disruption is whether it produces results in collisional modeling programs that are consistent with observations about the real asteroid population. For example, do plausible collisional scenarios lead to the preservation of Vesta's basaltic crust over the age of the solar system? Does the size distribution match that of the present asteroid belt?

In order to test models generated using both the hydrocode calculation and the Housen and Holsapple scaling law, we have incorporated each of them into our program for studying asteroid collisional evolution. Cases were then run using the same initial population of asteroids and collisional parameters, varying only the choice of the scaling law between the runs. We have explored different starting populations and choices of the critical collisional parameters, including some results derived from the hydrocode calculations.

We will summarize these results and discuss implications of the different scaling laws for the collisional history of asteroids based on our simulations of asteroid collisional evolution.

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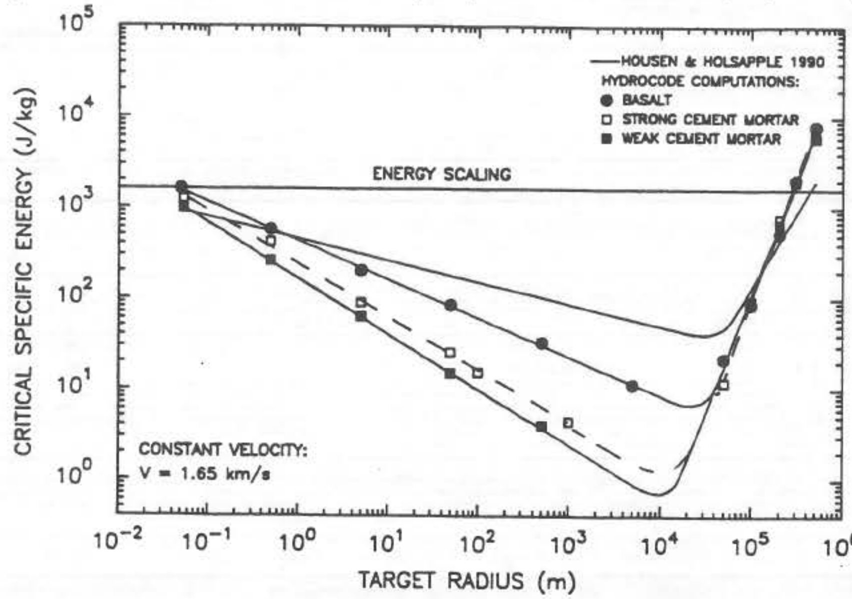

Figure 1. Hydrocode results for the dependence of critical specific energy Q^* on target size for basalt, and weak and strong cement mortar. Housen and Holsapple's (1990) nominal scaling law for basalt (solid curve) and energy scaling for basalt (solid line) are also shown. Impact velocity is kept constant at 1.65 km/s.

SPIN, POLE AND SHAPE DETERMINATION FOR SIXTY ASTEROIDS

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Introduction. The determination of spin axis and shape is well known to be fundamentally important for studies about the rotational and physical properties of asteroids. In particular, knowledge that the pole coordinate distribution is random or not could indicate the probable non-Maxwellian distribution of asteroid spin axes (see, e.g., [1]), while the distribution in terms of size and shape could place important constraints on the theories about the collisional history of some individual asteroids, of asteroid families, and of the asteroid population as a whole (see, e.g., [2], [3], [4], [5]). Many kinds of methods have been developped to determine pole coordinates (see, e.g., [6] and [7]). In this paper a composite method is applied to asteroid lightcurve data taken from literature.

Results for rotational and shape parameters (P_{sid} the sidereal period, λ_p and β_p the pole coordinates, a/b and b/c the axial ratios, β_A the phase angle coefficient, and the sense of rotation) have been obtained for sixty asteroids : for many of them it has been the first pole and shape determination, for many of them the shape parameters or the sidereal period and the sense of rotation have been obtained for the first time, for some of them the solution parameters have been substantially improved, for some of them the solution symmetry ambiguities present in asteroid pole solutions have been removed for the first time, and the value of the obtained parameters for already well-known asteroids are generally in agreement with those obtained by other authors.

Method. The method used in the present work is characterized by the combination of two complementary sources of information. First the lightcurve amplitude is compared with the light variation of a smooth, featureless triaxial ellipsoid rotating about its shortest axis, with geometrical scattering and with a semiempirical phase angle law (see [6] and [8]). This part of the analysis is known as the A method, and from this part alone the shape and the pole coordinates can be derived. The other part of the analysis is called the E method, and it is based on the fact that the changing relative geometry of the Sun, Earth and the asteroid (see, e.g., [6]) as they move in their orbits causes variations in the observed synodic period of rotation. The actual size and sign of these variations depend on the orientation of the spin axis and the sense of rotation, thus in principle the coordinates of the pole can be deduced by studying the changes in the synodic period. The E method is not based on any asteroid model, so from it no shape information can be derived, but sidereal period and sense of rotation can be obtained. In the present work, the E analysis has been performed with the "Photometric Astrometry" method ([9] ; [10] ; [11]), in the way used by Michalowski [12].

With this composite EA method the solutions are obtained with a simultaneous least square fit on both the E and A parts, with no trial pole solutions, so bypassing the problems given by each method taken alone.

Results. Pole and shape solutions have been obtained with the method shown above for 60 asteroids :

5 Astraea, 6 Hebe, 7 Iris, 8 Flora, 9 Metis, 15 Eunomia, 16 Psyche, 19 Fortuna, 21 Lutetia, 22 Kalliope, 29 Amphitrite, 32 Pomona, 39 Laetitia, 41 Daphne, 43 Ariadne, 44 Nysa, 45 Eugenia, 51 Nemausa, 55 Pandora, 63 Ausonia, 65 Cybele, 79 Eurynome, 83 Beatrix, 87 Sylvia, 88 Thisbe, 107 Camilla, 121 Hermione, 125 Liberatrix, 129 Antigone, 130 Elektra, 135 Hertha, 173 Ino, 196 Philomela, 201 Penelope, 216 Kleopatra, 238 Hypatia, 243 Ida, 250 Bettina, 281 Lucretia, 337 Devosa, 349 Dembowska, 354 Eleonora, 372 Palma, 389 Industria, 511 Davida, 516 Amherstia, 532 Herculina, 584 Semiramis, 624 Hektor, 683 Lanzia, 694 Ekard, 704 Interamnia, 747 Winchester, 776 Berbericia, 804 Hispania, 951 Gaspra, 1566 Icarus, 1620 Geographos, 1685 Toro and 1862 Apollo.

For many of these asteroids (83 Beatrix, 121 Hermione, 173 Ino, 238 Hypatia, 243 Ida, 281 Lucretia, 372 Palma, 389 Industria, 516 Amherstia, 683 Lanzia, 704 Interamnia, 747 Winchester and 776 Berbericia) this is the first spin, pole and shape determination, for some of them (8 Flora, 51 Nemausa, 1566 Icarus, 1862 Apollo and in some aspects 1620 Geographos and 1685 Toro) this is the first shape determination, for 8 Flora this is the first determination of sidereal period and sense of rotation, for 1566 Icarus the sense of rotation has been determined for the first time, and for many of them (8 Flora, 9 Metis, 21 Lutetia, 43 Ariadne, 87 Sylvia, 196 Philomela, 201 Penelope, 624 Hektor, 951 Gaspra, 1566 Icarus and in some aspects 532 Herkulina and 1862 Apollo) this one is the first pole solution resolved from ambiguities (see, e.g. [13]). For sake of brevity it is not possible to describe the solutions for each individual asteroid in detail. The values of the parameters obtained for other already well-known asteroids are in close agreement with those by other authors.

Conclusions. Solutions for parameters for asteroid rotation and shape have been obtained for sixty asteroids. All the parameters (P_{sid}, λ_p, β_p, a/b, b/c, β_A and sense of rotation) to describe the rotational and shape properties of an asteroid have been derived with a technique linking together the well-established E and A methods. The results have been strongly encouraging for further applications to a much larger sample of objects, and for possible future developments of the mathematical procedure.

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Theorem of the Minimum

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Abstract

In verymuch problems, particularly in the reductions of astrometrical plates, rectangular systems of equations (with more equations that unknowns) must be solved. The effect (error-effect) of an error acting upon an independent term (upon a star, in the reductions) is minimum at the center of gravity of the independent terms (at the center of gravity of the stars, in the reductions) only if the degree of the algebraic rectangular system (if the degree of the bijection between sky and plate, in the reductions) is odd. If the degree is even, the minimum is attained in all and each points of a circle centred in this center of gravity, which is a relative maximum. The value of the radius of this circle depends of the degree of the system (of the bijection, in the reductions) and of the number of equations (of the number of stars, in the reductions). Thus, the bijections of an odd degree must be taken (chosen) if we want the maximum of accuracy at the center of the astrometrical plate.

Theorem of the Proper Direction of the Elements of an Orbit

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Abstract

We consider the effect upon the orbital elements of a systematical error acting upon the observations. This error-effect is linear in function of the absolute value of the error and sinusoidal in function of the direction of this error. Thus, the zeros of the sinusoidal function give the direction with an effect equal to zero (proper direction).
This theorem must be taken into account in the cases of the existence of a systematical error in the stars catalogues, more accurately when the determination of such a systematical error would have been performed.

SOME DIAGNOSTIC POSSIBILITIES FOR STUDYING ASTEROIDS BY CIRCULAR POLARIZATION

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Attempts to use circular polarization V for studying atmosphereless bodies were undertaken at the end of the 1960s and were discontinued at the start of the 1970s because of its negligible values: V < 0.01% for the Moon. Mercury and Mars [1]. But our laboratory measurements of circular polarization [2] showed that low values of V are characteristic of materials with small absorption (dielectrics) and can be great for metals. Then atmosphereless bodies with expected great abundance of free metal in their material. namely S and M asteroids. can demonstrate appreciable circular polarization.

To establish possible values of circular polarization for these objects we made measurements of the Stokes vectors for different samples simulating asteroidal regolith. The laboratory Stokes polarimeter [2] designed and constructed at our Observatory was used. The basic material for the samples was a pyroxene powder (hyperstene 70%. enstatite 30%). Iron and nickel grains were added to pyroxene to produce samples with different ratio metal/pyroxene. Both metallic and pyroxene grains were less than 75 microns.

The circular polarization is found very small (V < 0.05%) for pyroxene powder. But its values increase linearly with metal content and can exhibit V > 1% for pure metal powders. Circular polarization depends on phase angle. changes in the trend of curve V vs.phase angle are due to surface structure.

Our measurements were made for homogeneous mixture of metallic and silicate grains to simulate the surface structure of undifferentiated asteroidal material. On the base of data for pure pyroxene and pure metals we calculated values of circular polarization for differentiated material. For the same ratio metal/pyroxene the calculated results fit to the measured results.

From the results it is concluded that

- circular polarization can be used for finding metals in asteroidal regolith and for evaluation of metal abundance in it:
- dependence of circular polarization on phase angle can give information about surface structure:
- unlike spectral characteristics [3]. circular polarization does not depend on differentiation of material therefore joint use of spectral and polarimetric results could give information about differentiation of asteroid material.

We should note that circular polarization can show observable values only for bodies of irregular shape or for separate regions of them and for phase angles more than 20 degrees. Thus the study of circular polarization can be realized mainly at space missions or for Near-Earth asteroids.

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COMETARY ORIGIN OF LUNAR CRATERS

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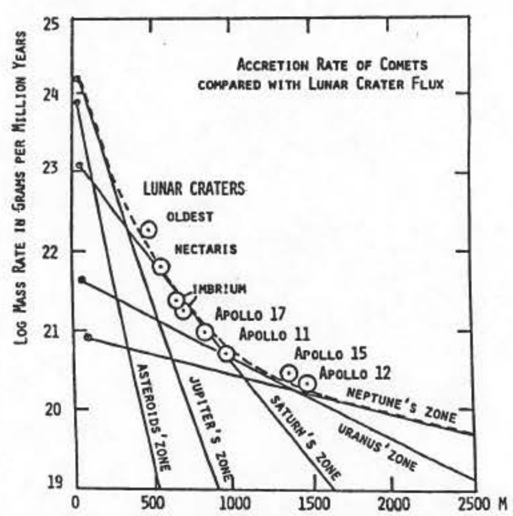
During the first billion years, the early intense cratering of the Moon was almost entirely due to the orbital diffusion of comets induced by the formation of the giant planets. This is demonstrated by the fit of the lunar cratering record with the diffusion model of the cometary orbits from the giant planets'zones. This diffusion starts immediately after the runaway growth of the giant planets'embryos, required by other considerations (Safronov 1991). The fact that the observed cratering rate can be duplicated by the sum of four exponential rates that are in proportion to the periods of the four giant planets is particularly striking.

The model proposed earlier (Delsemme 1981) was developed recently (Delsemme 1991, 1992, 1993). In my most recent revision, Hubbard's(1984) empirical data have convinced me to use larger masses for the giant planets'embryos. Aimed at predicting the comet contribution to the Earth's final stages of accretion, my model brings one order of magnitude more water and three orders of magnitude more gases than what remains now in the oceans and in the atmosphere. These amounts are welcome to justify the considerable losses of volatiles due to the late impacts of large planetesimals predicted by theory (Wetherill 1991). There is now a consensus (Ip and Fernandez 1988, Chyba 1991) on the order of magnitude of cometary matter brought to Earth by this mechanism.

The present paper represents my first effort to introduce a chronology in the diffusion of the cometary orbits, in order to understand how this bombardment interfered with the final accumulation of the Earth. I call time scale for orbital diffusion, the time for the number of scattered bodies to diminish by a factor of 1/e. In 1972 I used 60 million years for that of Jupiter's zone. Numerical experiments done by Everhart (1977) have convinced me to revise it to 70 million years. The other time constants are in proportion to the giant planets'periods. The early mass in the asteroid belt is assumed to be 10 Earth masses. This leads to the following data:

Relevant zone:	Asteroids	Jupiter	Saturn	Uranus	Neptune
Epoch for onset (10^6yr)	10	10	20	50	80
Time scale (1/e)(10^6yr)	28	70	175	410	820
Mass rate (10^{23}g/10^6yr)	8.8	17.0	1.12	0.060	0.008

The following figure shows the same results graphically. On this logarithmic diagram, the exponential time scales are straight lines. The sum of all contibutions is the dashed line. The data for the Moon cratering rates (Carr et al.,1984) have been normalized to the same units and represented by circles with a central dot. Extrapolating the model to the present predicts that the Neptune contribution is not quite finished. This can be interpreted as the short-period comets, coming from Neptune's period resonances in the Kuiper belt. Our model predicts one comet still hitting the Earth every 20 000 years. This is not too farfetched for such a simpleminded model. One conclusion seems inescapable: practically all lunar craters come from cometary stuff.



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LIGHT CURVES OF SOME ASTEROIDS

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A new observational programme has been started at Department of Astronomy, Bulgarian Academy of Sciences: photometry of asteroids, aimed determination of their spin vectors. For this purpose and taking account possibilities of the used telescope several asteroids were selected. First observations were carried out with the electrophotometer at 60 cm Cassegrain telescope of Belogradchik Observatory. In this paper we present the obtained light curves of the observed asteriods.

Where to Look for Low Inclination Objects in the Kuiper Belt

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The recent search in the plane of the ecliptic for objects in the outer solar system resulted in the discovery of 1992QB1 (Jewitt and Luu, 1992) in a low inclination orbit. We point out that the plane of the ecliptic may not be the best place to search for objects in very low inclination orbits, particularly if very small fields of view are used, and that it would be better to conduct such searches in the Laplacian plane.

OBSERVATIONS OF COMET P/SWIFT-TUTTLE 1992t AT IRAM.

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The millimetre spectrum of P/Swift-Tuttle, the comet responsible for the Perseid meteor stream, was observed with the IRAM 30-m telescope on November 11-14 and 21, 1992, and on January 6-7, 1993. These dates bracket the perihelion, which took place on December 12. The distance to the Sun was about 1.1 AU and the distance to the Earth increased from 1.2 AU for the first period to 2 AU for the last one.

The following molecules were detected, with signal-to-noise ratios ranging from 7 to 30 (November 21): HCN (J(1-0) line at 89 GHz) ; CH_3OH (12 lines around 145 and 165 GHz) ; H_2S (1_{10}-1_{01} line at 168.8 GHz) ; H_2CO, (3_{12}-2_{11} line at 225.7 GHz). In January, HCN, CH_3OH and H_2CO were also observed, which will allow a comparison of the molecular productions before and after perihelion.

From the line intensities, we evaluate the molecular production rates relative to water on November 21 to be 0.25 10^{27} s^{-1} for HCN, 2. 10^{28} s^{-1} for CH_3OH, 1.5 10^{27} s^{-1} for H_2S and 2 10^{27} s^{-1} for H_2CO (assuming a parent-molecule distribution for this latter molecule). The water production rate at that moment, estimated from OH observations, was of the order of 5 10^{29} molecules s^{-1}.

The simultaneous observation of several rotational lines of methanol will permit to evaluate the rotational temperature of this molecule and to constrain the physical conditions within the coma.

All line profiles are asymmetric with a cusp at negative velocities. They are blueshifted by 0.5-0.7 km s^{-1}. It is the first time so important radio line shifts are observed in a comet.

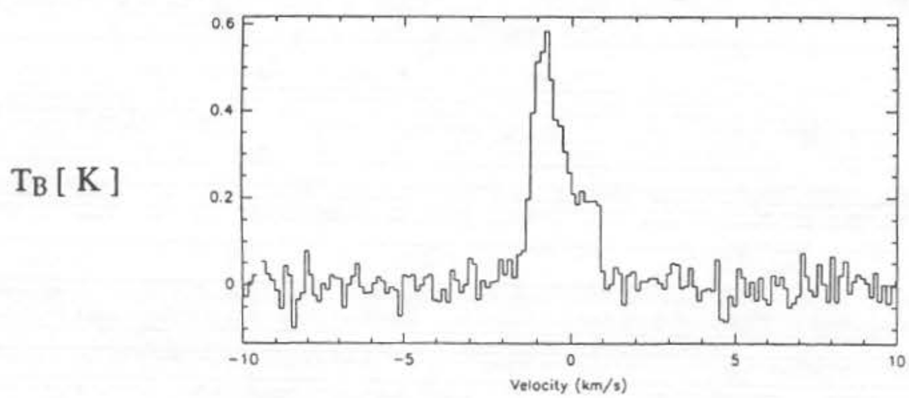

Fig. 1 P/Swift-Tuttle on November 21, 1992 : H_2CO 3_{12}-2_{11} line at 225.7 GHz .

STATISTICS OF ASTEROIDS

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A statistical investigation of asteroids has been carried out. The distributions by orbital elements are presented. The structure of the Asteroidal Belt is discussed.

Lightcurves and Rotational Periods of 1981 Midas and 1993 BX3: Two Large Amplitude Apollo Asteroids.

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S. Mottola
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We present photoelectric and CCD lightcurves of the Apollo asteroids 1981 Midas and 1993 BX3, a newly discovered object, obtained at the European Southern Observatory during their apparitions in 1992 and 1993, respectively.

From the preliminary analysis of the collected data we have determined the rotational period of these objects. The large lightcurve amplitude shown by both asteroids is an indication of their elongated shape.

Hydrodynamical approach to the stability of the Asteroidal belt

C. Dinev

ABSTRACT. It is well known that the hydrodynamical eguations are applied for investigation of a given system, if in this system the Knudsen number (Kn) is less than 0,2. In the present paper the Kn is callculated on the basis of the commonly accepted estimations of the body's number in the Asteroidal belt and the mass of the Asteroidal ring. It is shown that the asteroids satisfy the above mentioned condition. The behaviour of the asteroids is treatted as a thin gas disk. The hydrodynamical criteria of the secular stability are developped. They are very simple and describe the Kirkwood's gaps and the asteroidal families.

Trends In Cometary Magnitude Data

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Abstract

The brightness distributions of long-period comets with P > 200 years, intermediate-period comets with 15 < P < 200 years (Halley-type comets) and short-period comets with P < 15 years (Jupiter family of comets) were modelled by Pareto power law distributions. The models were fitted using maximum likelihood methods and analyzed using a new trend analysis approach. The long-period comets were divided into a number of physical parameter ranges, notably by perihelion and discovery date ,and examined for appropriate physical trends. Similarly, the short-period and intermediate-period comets were examined for such trends particularly with increasing orbital period. Overwhelming evidence was found that brightness indices increase with discovery date for long-period comets.

OBSERVATIONAL RESULTS AND MODEL OF 243 IDA

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During last year we carried out an observational campaign on the asteroid 243 Ida in order to achieve the maximum possible information from ground–based observations before its Galileo fly-by.

We have carried out our observations at the Pic du Midi, (December, 26–28 1992; January, 16–21 1993) and Haute Provence (December, 25–29 1992; January 24–February 1 1993) and Granada (November, 14–24 1992) observatories and our observational program continues at the European Southern Observatory (April, 12-20 1993) with the aim to obtain reflectance spectra, UBV photometric lightcurves and IR data. These data will be used to study the surface composition and to propose a model of large scale surface features of this asteroid.

The model of 243 Ida is obtained numerically using an algorithm developed by Barucci *et al.* (1992) that, by using as baseline model a regular triaxial ellipsoid, produces synthetic lightcurves. The comparison between the observational lightcurves and the synthetic ones allow us to hypothize the local morphological variations which, modifing the baseline shape of the asteroid, cause the peculiar lightcurve features.

We will present the observational results. The models, obtained using as pole orientation both that determined by Magnusson et al. and the one by T. Michalowski (private comunications), will be discussed.

Barucci M.A., Cellino A., De Sanctis C., Fulchignoni M., Lumme K., Zappalà V. and Magnusson P.: 1992 Ground–based Gaspra modelling: comparison with the first Galileo image. Astron. Astrophys. 266, 385–394.

NEW EVIDENCE FAVORING MINOR BODY ORIGIN AND PROPERTIES BY VIRTUE OF ELECTROLYZED ICE CHEMISTRY

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New Eruptive Cosmogony (NEC) of minor bodies is based on a single physically quite realistic assumption on a possibility of accumulation in Callisto-type body icy envelopes of the volumetric electrolysis products up to concentration making possible their detonation. Basing on NEC, not applying for new hypotheses we succeeded both in realizing origin and main properties of asteroids, including Trojans, SP comets, Martian and Jovian minor satellites, Saturnian rings and atmosphere of Titan, and in offering a series of predictions, some of them have been confirmed (Titan radius and its atmospheric composition, burning of sublimation products in comets, etc.), while others are still awaiting their verification (e.g. an excess thermal flux from Titan after its recent explosion) (E.M. Drobyshevski, Earth, Moon, & Planets, v.44, 7, 1989, and refs. therein).

NEC anticipates a presence in cometary ices, besides organics, of free oxygen and hydrogen also that provides a burning in the sublimation products at the verge of energetical possibility and under the oxidizer deficiency. The approach proposes a single explanation for many long-known phenomena such as the nucleus break-ups and outbursts and their correlation with the Solar activity, postperihelian increase in cometary activity, constancy of CH/C2 ratio in 0.5-1.5 AU, OH excess relative to hydrogen in P/Churyumov-Gerasimenko, etc.

Missions to P/Halley revealed a lot of facts which are hardly fit to the classical sublimative-photochemical models without invoking numerous extra hypotheses. The NEC conclusion on the combustion possibility enables one to explain with no stretch both the anew-discovered peculiarities of energetics of near-nuclear processes and their chemistry. These are high sublimation rates from the small area sources and the great outflow velocity of gas and dust, manifold excess of CO over CO2, presence of atomic carbon and ions in the close nucleus vicinity, origin of CHON particles (a familiar smoke), etc. (E.M.Drobyshevski, Earth, Moon, & Planets, v.43, 87-99, 1988). Results of P/Grigg-Skjellerup fly-by demonstrating many differences with P/Halley might be explained but again remaining within the framework of combustion by taking into account the quenching of reaction products due to their expansion in vacuum proceeds here earlier due to a lower gas release rate from the nucleus.

A close scrutiny of facts contradicting, at first glance, to NEC, - such as the low density of a comet nucleus or the ortho/para water molecule ratio (OPR), - discloses that the nucleus density could be raised up to ~1 g/cm3 with taking into account the jet pattern of outflows, whereas OPR = 2.3 measured at P/Halley could be created just by the kinetic processes involving highly active combustion products which, when expanding into vacuum, lower their temperature to ~25 K.

Findings of negative ions in P/Halley coma and its distant outbursts were surprising to discoverers themselves, but again they can be explained by the combustion of nonhomogeneous substance. One can perceive chemical difference of different comets, aqueous alteration of cometary particles, existence of high-temperature meteoritic kerogen-like material, the distant cometary appearance of Chiron, which is a plausible fragment of Titan's recent explosion. Possibly, an object 1991DA which experienced a close approach to Saturn not so long ago, is of the same origin.

EXPLOSION OF PHAETHON CAN EXPLAIN THE DISTRIBUTION OF ASTEROIDAL TAXONOMIC TYPES. E. M.Drobyshevski[1], V. A.Simonenko[2], S. V.Demyanovski[2], A. S.Shnitko[2], V. A.Sutchkov[2], and A. V.Vronski[2], [1]Ioffe Phys.-Technical Institute, Russian Academy. of Sciences, 194021 St.Petersburg, Russia, [2]Institute of Technical Physics, 454070 Chelyabinsk, Russia.

The observed distribution of different type (S-M-C) MB asteroids vs. the solar distance is considered usually as favoring their accretional origin, against the appearance due to disruption of Phaethon—the moonlike planet between Mars and Jupiter. Below, basing on the latter presumption, we will show how Phaeton's explosion had created by the natural way the distribution of the taxonomic classes.

The New Eruptive Cosmogony of minor bodies is based on a sole assumption on a possibility of accumulating $2H^{2+}O^{2-}$ products of the dirty ice bulk electrolysis in massive icy envelopes of distant Callisto-type moonlike bodies in a form of a solid-state solution up to concentrations (~10–15 wt.%) allowing the selfsustained detonation of such an "ice" to be possible (Drobyshevski (1980) *Earth, Moon, Planets, 23,* 339; Drobyshevski (1986) *Earth, Moon, Planets, 34,* 213). The detonation is initiated by a heavy meteoritic impact breaking through the outermost ~100-km-thick icy crust saturated by the electrolysis products also. But the stable detonation in the crust is impossible as due to the surface-caused off-loading of compression waves (so-called Khariton's layer) and due to minimal energetic conditions are not met here because of a lower temperature. So the detonation proceeds in the underlying mass of the ice envelope.

Two-dimensional calculations of an impact-initiated explosion of the electrolyzed ice envelope of a body with M < 0.5 Mmoon, when the explosion energetics is sufficient for the total disruption of the planet, shows the fragments dynamics of the noncentral explosion is able to propose an explanation to observable distribution of the asteroidal main types vs. the solar distance. In the case of interest, the detonation had to be initiated in the trailing hemisphere of Phaethon.

Then, due to the gravitation field change during the explosion, the detonation products of the electrolyzed ice would fling the icy fragments of the outermost nondetonating layer in a forward direction mainly, i.e., in the more distant orbits. These fragments, which have been exhibiting the cometary activity at first, became the C-type asteroids after their surface ice sublimation and radiative reworking of the surface. The electrolyzed ices resided in some of them are able to new explosions at new impacts. Phaethon's rocky core, being disrupted by the explosion, is rejected by recoil at back, viz. in the initial impact site direction. These rocky fragments, which gave rise to S-asteroids, found themselves at more close-to-Sun orbits.

And finally, the inner iron core fragments due to their great density remain in a mean near the initial orbit of Phaethon giving rise to M-asteroids. The central iron core could have appeared in Phaethon owing to an excess Ohmic heating its interior by electric currents which simultaneously performed the ice electrolysis in the envelope.

Subsequent mutual collisions of fragments, along with the secondary collision-caused explosions of the ice-containing great C-type asteroids, seem to be capable of producing the observable kinematic features of MB asteroids.

The Collisional History of the Mainbelt Asteroid Population and Hirayama Asteroid Families

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A self-consistent model of the collisional evolution of the mainbelt asteroids is presented, with emphasis on the collisional history of asteroid families. Using a runaway growth initial size distribution based upon the work of Wetherill (1992, private communication) and a modified size-strength scaling law, we have been able to match in detail the observed size-frequency distribution of the mainbelt asteroids. After 4.5 billion model years of collisional evolution we are able to fit: (1) the excess of asteroids at $\approx$100 km diameter, (2) the transition to an equilibrium distribution for diameters $\lesssim$30 km, (3) the absolute number of asteroids in the equilibrium population, and (4) the extended "tail" of asteroids larger than $\approx$350 km. During a model run we also follow the collisional evolution of families of fragments resulting from single breakup events representing the formation of Hirayama asteroid families. Thus, for the first time, we examine the collisional evolution of asteroid families due to impacts by a projectile population which is itself collisionally evolving toward the observed distribution.

DYNAMICAL EVOLUTION OF LONG-PERIOD COMETS AND METEOR STREAMS.

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The dynamical evolution of long-period comets and meteor streams is considered by using the mappings describing planetary perturbations in an analytical form for any nearly-parabolic orbit [1]. The comparison with numerical integration has shown the great efficiency of this method. The formulae that permit us to take into account close encounters and nongravitational effects have been obtained.

A distribution like the Oort cloud is a typical stage of the evolution of comets in nearly-parabolic orbits under planetary perturbations. The general picture of the evolution of the distribution function over w = 1/a (a is the semimajor axis) does not vary significantly with the initial value of w. Nongravitational forces are important aspects of the transformation from long-period orbits into short-period orbits. For the typical nongravitational forces, w5–10% of initial nearly parabolic comets with perihelion distances w1 AU evolve quickly to orbits with aphelia inside Neptune's orbit. It is quite possible that the observed distribution of comets has arisen by the action of planetary perturbations for 3–5 Myr. For the orbits of classes I,II from [2], the observed ratio of the number of "new" comets to that of "old" comets is obtained, when a mean observable lifetime is less than 10 revolutions. However, there is a difficulty of explaining the number of long-period comets with w r 0.006 (1/AU).

The above-mentioned method has allowed us to study the evolution of long-period meteor streams as well. Models of the ecliptic cross sections of the Perseid, Eta-Aquarid, Orionid, and Lyrid meteor streams have been constructed. Most particles of the Perseid stream cross the ecliptic plane in the range 0.9–1.1 AU from the Sun. The Orionids and Eta-Aquarids are distributed in the ecliptic cross section near a certain line that may reach to the orbit of Neptune. The position of this line is hardly dependent upon the initial conditions of modelling. The possibility of a short-term outburst in the activity of the Lyrids in 1994 is noticed.

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Pole Orientations and Shapes of Asteroids

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Abstract

Pole orientations and shapes of asteroids are fundamental parameters for studying evolutionary and collisional processes in the asteroid belt. There are reasons to expect that asteroid spin vectors and shapes are correlated to a number of parameters such as size, heliocentric distance, taxonomic type and family membership and that an analysis of these relations will yield important new cosmogonical information.
In order to study these relations a large number of spin vectors have to be determined and we have an ongoing observational campaign, mainly conducted with the ESO 1 meter telescope, to obtain the needed amount of data. Some first results will be presented.

NEAR-EARTH ASTEROID RENDEZVOUS (NEAR). R. Farquhar, A. Cheng, T. Coughlin, and D. Dunham, Applied Physics Laboratory, The Johns Hopkins University.

NASA is planning to initiate a new program of low-cost planetary missions called the "Discovery" Program. Discovery missions will have focused scientific objectives and strict limits on project costs and development time. In 1991, the Discovery Science Working Group recommended that the first mission of the Discovery Program should be a rendezvous with a near-Earth asteroid. The selected target for the Near-Earth Asteroid Rendezvous (NEAR) mission is the small near-Earth asteroid 4660 Nereus (formerly known as 1982 DB). NEAR is currently scheduled to be launched in January 1998 with a rendezvous at Nereus in January 2000. It is planned to carry out a flyby of the main-belt asteroid 2019 van Albada prior to the Nereus rendezvous, as well as flybys of several near-Earth objects during a proposed extended-mission phase. A simple, robust spacecraft has been designed that can accomplish the NEAR mission within the Discovery Program cost guidelines. The science payload weighs about 50 kg and includes a visible imager, an imaging spectrograph, a gamma-ray spectrometer, and a magnetometer.

The Radio Spectra of the Jovian Satellites Ganymede and Callisto Compared with Spectra of Rocky Asteroids

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Henry E. Matthews
Russell O. Redman
Ian Halliday

Measurements of the continuum thermal flux densities of the Jovian satellites Ganymede and Callisto from 2 mm to 0.35 mm wavelength made with the James Clerk Maxwell Telescope in December 1989 (Matthews et. al., 1990) are combined with published measurements at other wavelengths to construct the total thermal spectra of these objects. In spite of the fact that their surfaces are believed to be dominantly made of water ice, their spectra strongly resemble those of rocky asteroids. We will discuss whether it is possible to distinguish an icy surface from a rocky surface using only radio data.

The Abundance of Ammonia in Some Recent Comets

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The abundance of ammonia, relative to water, in cometary ice remains an open question. Values for comet P/Halley derived from a variety of remote and *in situ* observations range over an order of magnitude from 0.1% to 1–2%. Recently, we presented a derivation based on an analysis of the spatial distribution of NH emission in the $A\,^3\Pi - X\,^3\Sigma^-$ (0,0) band at 3360 Å as measured by the Russian *ASTRON* satellite (Feldman *et al.*, *Ap. J.* **404**, 348, 1993). The large spatial extent of the data permitted a novel method of analysis that is largely independent of the details of a photodissociation model, many of whose parameters are only poorly known. For 9 April 1986, this analysis gives a ratio of NH_3/H_2O production rates in the range of ~0.5–1.0%. Simultaneous observations of NH on the same date by the *International Ultraviolet Explorer* (*IUE*) allow us to infer NH_3/H_2O abundances on other dates for comet P/Halley (including the time of the *Giotto* encounter) as well as relative abundances in other moderately active comets for which the *IUE* data has satisfactory signal/noise ratio. We have extended this analysis in two aspects, accounting for the variability in gas production rate of P/Halley, and allowing for the effects of differing geocentric distance (the effective size of the spectrograph aperture projected onto the comet) for different *IUE* observations. Where possible we present direct comparisons with relative abundances derived from ground-based observations of NH_2.

The Evolution of the Coma of Comet P/Swift-Tuttle During November 1992

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The *International Ultraviolet Explorer* (*IUE*) satellite observatory was used to determine the abundances of OH, CS, O, C and S in the coma of periodic comet Swift-Tuttle (1992t) during the period 3–23 November 1992 on 4 separate dates. The heliocentric distance decreased from 1.17 AU to 1.01 during this period. On 3–4 November, during a 16 hour observing shift, visual photometry using the *IUE* Fine Error Sensor showed a variation of ~40% with a clear maximum near 02:00 UT on November 4. The ultraviolet emissions, sampled three times during this period, appear to follow this variation, although with characteristic phase lags. The water production rate, deduced from the observed OH emission, increased rapidly with decreasing heliocentric distance, following an approximate r^{-n} law with n between 6 and 9 (the uncertainty is due to the short-term variability) and reaching a value of $\sim 5 \times 10^{29}$ molecules s^{-1} on 23.9 November. This makes P/Swift-Tuttle the most active comet at 1 AU to appear since P/Halley. While our data are insufficient to determine a rotation period, they are consistent with periods in the range of 2.6–2.9 days and can exclude a period of less than one day.

DYNAMICS OF COMETS: RECENT DEVELOPMENTS AND NEW CHALLENGES

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There is a broad consensus that long-period comets come from a huge reservoir surrounding the solar system, as proposed originally by Oort. Yet, the classical picture of the Oort cloud has substantially changed during the last decade. In addition to passing stars, giant molecular clouds and the tidal force of the galactic disk have been identified as major perturbers of the Oort cloud. In particular, giant molecular clouds may be responsible for limiting the size of the stable Oort cloud to no more than $\approx 3 \times 10^4 AU$, i.e. about one third of the classical Oort's radius.

Most comets are injected into the planetary region by the quasi-steady action of the tidal force of the galactic disk. The concentration of aphelion points of new and young long-period comets toward mid-galactic latitudes is a consequence of its dominant influence. Some clusterings of aphelion points not associated with the galactic structure may be signatures of close stellar passages in the recent past. Their invoked association with the solar antapex remains as a very controversial issue.

The frequency of comet passages by the inner planetary region could experience significant fluctuations with time as the Oort cloud meets random strong perturbers. In particular penetrating encounters with giant molecular clouds and stellar passages at distances of a few $10^3 AU$ may trigger comet showers as intense as $10^2 - 10^3$ times the background comet flux at average intervals of a few 10^8 years. The observed ordered pattern of most comet aphelia associated with the galactic structure argues against a recent strong perturber of the Oort cloud able to blur it, thus suggesting that the current frequency of comet passages is near its quiescent level.

Comets covering a wide range of dynamical ages (from near parabolic orbits down to periods $P \cong 20$ years) can be satisfactorily explained as a multiple-step capture process by Jupiter. This mechanism cannot be applied to the Jupiter family comets (periods $P < 20$ years) because of the difficulty -if not impossibility- to explain in this way some of their properties, in particular the lack of retrograde orbits. This suggests another dynamical path for the Jupiter family comets that goes through the transjovian region. Objects like P/Schwassmann-Wachmann 1 and Chiron may be suitable precursors of the Jupiter family. The problem is to identify possible sources of the outer solar system objects. So far, two appear as the most promising ones: 1) The capture of Oort cloud comets by Saturn, Uranus and Neptune. For this mechanism to work properly it is required that the capture of low-inclination orbits be strongly favored and that it provides the right number of comets to explain the population size of the Jupiter family. 2) The transfer of comets from a transneptunian comet belt, the so called Kuiper belt. The question here is to identify the dynamical mechanism(s) responsible for transferring belt comets to Neptune-crossing orbits. It is possible that secular perturbations by the giant planets may be able to remove belt comets over the age of the solar system.

A new picture of the comet reservoir is emerging in which it stretches from just beyond Neptune to several $10^4 AU$, passing from a flat structure to a spherical one. The Kuiper belt can become accessible to large telescopes, as shown by the recent discovery of $1992QB1$, possibly a belt member. The major challenge will be to explore the region usually unaccessible to external perturbers that goes from several tens AU to a few thousands AU. A significant mass may have been locked there from the beginnings of the solar system, giving rise to an inner core that feeds the outer or classical Oort cloud. Our aim will be to briefly discuss some of the topics summarized here.

NEAR-UV OBSERVATIONS OF 4179 TOUTATIS

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We observed the fast moving asteroid 4179 Toutatis using the International Ultraviolet Explorer (IUE) spacecraft at the time of its closest approach to the Earth on 10-11 December 1992 ($\Delta = 0.28$–0.32 AU). Four long wavelength ($\lambda\lambda \sim 2400$–3300 Å) UV spectra were obtained that allow the determination of the albedo and the UV color of this small, slowly rotating object. The middle of the first and last spectra were exposed 22 hours apart, thus allowing a limited study of the UV rotational variation of 4179 Toutatis' lightcurve. The IUE data permit us to extend the spectrum of this unusually well observed asteroid significantly below the atmospheric cut-off. Additionally, these data permit comparison of the spectral properties of Toutatis with those of asteroids previously observed with the IUE spectrographs, in particular the large asteroid 4 Vesta.

A DS FORMULATION FOR HYPERBOLIC-TYPE MOTION ALONG SMALL-PERICENTRE-DISTANCE ORBITS UNDER OBLATENESS PERTURBATIONS

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Abstract

The present research was originally inspired by Hori's article *The Motion of a Hyperbolic Artificial Satellite around the Oblate Earth* ("Astronomical Journal" **66**, (1961), pp. 258-263) in which a canonical set of six Delaunay-like variables was derived and which is applicable to the study of hyperbolic orbital motion; in that paper this set was used to work out a first-order analytical solution to the zonal oblateness problem of motion of a hyperbolic satellite. His way of proceeding was based on an appropriately devised modification of the von Zeipel perturbation method leading to the determination of the first-order terms of the generating function for a near-identity canonical transformation with the help of which the first-order variations due to the flattening of the central body were calculated.

In a parallel way, this paper proposes a simple mathematical and dynamical model for the approximate investigation of *close-to-pericentre orbital motion of a non-recurrent small mass* within the framework of positive-energy two-body problems under the perturbing influence emanating from the major term of the zonal gravitational potential due to an *oblate spheroidal primary.* The approach taken in the present study resorts to the following main aspects of the question of investigating some of the principal features about the same basic J_2-problem:

- *true-anomaly DS-type elements* are derived in the 8-dimensional, extended phase space that are applicable to *hyperbolic two-body motion*;
- the above dynamical problem is then formulated in such variables;
- with the aim of obtaining an *approximate analytical solution* to the considered problem by accomplishing *a first-order integration* of the new Hamiltonian, the elimination of the first-order trigonometric terms occurring in the corresponding, transformed Hamiltonian is undertaken in the extended phase space by adapting and taking advantage of the ideas expounded in the aforementioned paper by Hori.

To be precise, an infinitesimal contact transformation controlled by a generating function is introduced whose first-order part is specified by integrating the first-order equation of the von Zeipel procedure and replacing the customary periodicity conditions on the unperturbed Kepler problem (holding in bounded states of motion in the two-body problem) by the device of *imposing conditions at* $r = \infty$.

To fully achieve the development and representation of the sought solution, the *first-order deviations from the Keplerian reference orbit* due to the J_2- disturbing influence are derived with the help of the above generating function of the transformation according to the standard procedure for setting up the perturbation equations.

The approach taken in the present research allows one to reformulate the theory, previously built up by Hori in employing hyperbolic Delaunay variables, in terms of hyperbolic DS elements that use the true anomaly as the independent variable.

IDENTIFICATION OF COMETARY DUST AMONG THE INTERPLANETARY DUST COLLECTED FROM THE EARTH'S STRATOSPHERE; G. J. Flynn, Dept. of Physics, SUNY-Plattsburgh, Plattsburgh, NY 12901 USA.

The distribution of peak temperatures reached on atmospheric entry suggests a large fraction of the interplanetary dust particles (IDPs) collected from the Earth's stratosphere are derived from main-belt asteroidal parent bodies (1). This is consistent with inferences from IRAS data and orbital modeling suggesting that catastrophic collisions in the main-belt provide a sufficient amount of dust to resupply the zodiacal cloud (2, 3). However, comets are observed to contribute dust to the interplanetary medium, and some of the IDPs collected from the stratosphere can be identified as cometary by thermal criteria.

Main-belt asteroidal IDPs generally have geocentric velocities $\leq$6 km/s (1, 4) at Earth encounter. This limits their atmospheric entry velocities to $\leq$12.6 km/s, restricting the peak temperatures reached on atmospheric entry. The peak temperatures reached by main-belt asteroidal IDPs under the most extreme entry conditions (highest velocity and normal incidence), calculated using the model Whipple model (5), are shown in Figure 1.

Internal indicators of the peak temperature reached on atmospheric entry, such as the presence of volatile elements, low-temperature mineral phases, radiation damage tracks, and/or solar wind implanted noble gases, can be used to separate the IDPs collected from the stratosphere into two groups: one consisting of particles heated more extremely than is possible for main-belt asteroidal particles of that size and density, and a second consisting of particles which have experienced less extreme heating. The first group contains only comet particles and the rare particles from asteroids in highly eliptical or highly inclined orbits. The second group contains a mixture of main-belt asteroidal particles and cometary particles which encountered the Earth at shallow incidence angles.

Individual stratospheric IDPs which have a high probability of cometary origin have been identified, and their chemical, physical, and mineralogical properties will be described.

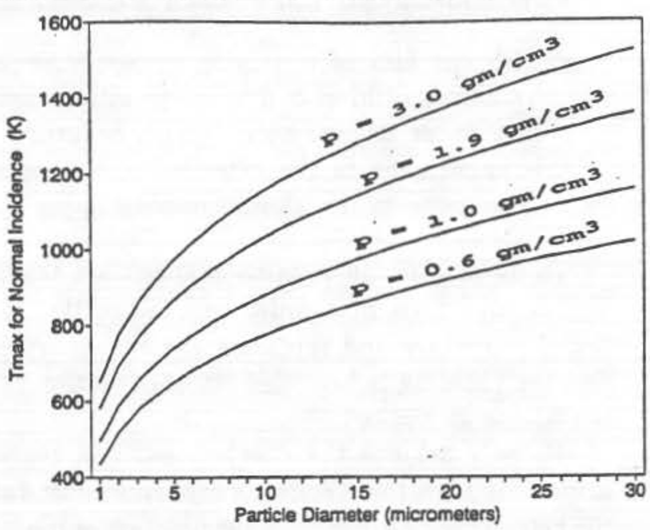

Figure 1. Peak temperature (T_{max}) reached by main-belt asteroidal particles during Earth atmospheric entry versus particle diameter and density (p). The modeling assumed normal incidence and an entry velocity of 12.6 km/s.

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THERMAL-INFRARED IMAGING OF COMETS; M. Fomenkova[1], B. Jones[2], R. Pina[2], L.-A. McFadden[1,3]; [1] - CalSpace Institute, University of California San Diego, La Jolla, CA 92093-0216; [2] - CASS, University of California San Diego, La Jolla, CA 92093-0111; [3] - Astronomy Department, University of Maryland, College Park, MD 20742-2421

Comets are known to be strong infrared sources because of thermal emission of dust grains ejected by their nuclei. Observations at thermal wavelengths are very useful in assessing the physical properties of the dust and of the nucleus itself.

Fifteen images of a dynamically "new" comet, Austin (1989c), were obtained on May 5-12 (UT), 1990, on the Mount Lemmon Observing Facility's 1.5 meter telescope (Tucson, Arizona) with the UCSD mid-infrared array camera. The camera has a format of 64x16 pixels with a plate scale of 0.83 arcsec/pixel (which twice samples the core of the telescope diffraction pattern at 10 μm). The somewhat marginal quality of the data reflects the early engineering status of the camera at the time the observations were made and mandates caution in interpretation of the data. Flux calibrations were obtained using the stars β Peg, α Lyr, and α Sco.

The finite spatial resolution of cometary measurements puts a limit on the time scale of variability which can be detected. For an aperture of angular size ϕ centered on the nucleus, the "aperture escape time" for dust ejected from the nucleus is [1]: $\tau(\phi)$ *[hrs]* = 0.35 x ϕ *[arcsec]* Δ *[AU]* $r^{1/2}$ *[AU]*, where Δ is the geocentric and r is the heliocentric distance. With an array format of 53x13 arcsec, the aperture escape times for the Comet Austin images are 6.6 and 1.6 hours respectively, and the 2-pixel (minimum resolution) crossing time is 0.4 hours. Thus, images obtained on different nights are not expected to appear the same and they do not. Images obtained on the same night may show variability but appear similar within the accuracy of the data.

Radial brightness profiles have been constructed for each date of observation by averaging all images obtained on that date. All the profiles indicate a slope of -1, consistent with a steady state model, up to an angular distance of 4-5 arcsec (10^3 km) from the nucleus. Beyond that, the profiles steepen to about -1.25. One hypothesis is that the steepening may be due to the shaping of the coma by solar radiation pressure. However, the radial distance at which the dynamical effect of solar radiation pressure becomes important is typically $3\text{-}5 \times 10^2$ km ($>>10^3$ km). A more plausible hypothesis is that the number of grains begins decreasing faster than ρ^{-2}. Hanner [3] has estimated that icy grains should have a maximum radial extent of only $10^2\text{-}10^3$ km. This is somewhat more consistent with our data.

The majority of our images were obtained with a broad 9-12 μm filter bracketing the peak in black-body emission. Thus, the integrated flux is proportional to the total thermal emission and is predicted to vary as r^{-4}. The measured dependence $r^{-5.5}$ can be accounted for if the dust production rate falls as r^{-3} (r^{-2} due to the temperature decrease and $r^{-0.5}$ due to the decrease of the grain terminal velocity).

Comet Austin had an unusually wide silicate emission feature [4]. On May 12, we acquired one image with the 9-12 μm filter and two images with a narrower 8-9 μm filter. A ratio of these images was examined to determine the spatial distribution of the silicate emission. The emission was found to be strongest within a 90 degree angle in the sunward direction with the peak at a distance of 2000 km. Observations of Comet Halley [5] also indicated silicate emission in the sunward direction. However, the peak emission was located at the nucleus.

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ACTUAL METEOR PRODUCTION OF COMET P/SWIFT-TUTTLE 1992t

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The numerical inverse model of comet dust tails (Fulle 1989) is applied to wide field Schmidt images of the dust tail of comet P/Swift-Tuttle 1992t, in order to establish the actual production of meteors of the well known Perseid stream. The input images contain information on grains of sizes between 0.01 and 10 mm ejected during the time interval -150 < t < -20 (days related to perihelion). The tail fits are extremely sensitive to the anisotropy of dust ejection: it is impossible to fit the observed tail with isotropic or strongly anisotropic ejections, whereas Sun faced hemispherical dust shells allow to build up model dust tails in good agreement with the observed ones. This closely agree with the conclusions of Sekanina (1981), who pointed out that the well known jets of the inner coma can be explained only admitting a strong activity of many spots even very far from the Sun culmination. The dust ejection velocity of particles of 0.15 mm diameter increases from 20 m/s at t = -150 days, to 50 m/s at t = -20 days. The loss rate is about constant over the considered time interval at about 5000 kg/s (for a dust albedo for the phase function of 0.06, Hanner and Newburn 1989). The power index of the time averaged size distribution is -3.3, thus pointing out that the dust production of P/Swift-Tuttle is dominated by meteoroids. In fact about the 95% of the produced mass (reaching at least 10^11 kg for the 1992 passage) is injected in the Perseid meteor stream.

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SPIN AXIS ORIENTATION OF 2060 CHIRON FROM DUST COMA MODELING

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The numerical inverse model of comet dust tails (Fulle 1989) is improved in order to take into account possible effects of the nucleus rotation on the dust shell axis orientation, and is applied to the asymmetric dust coma image of 2060 Chiron (West 1991). Tests of the model allow to prove that the dust shell axis orientation (i) strongly affects the coma image fits, (ii) is uniquely determined and (iii) introduces changes of the second order in the solutions (loss rates and size distribution) with respect to other non linear free parameters (time and size dependence of the dust velocity and ejection anisotropy). The comparison of our results with those of coma photometry allows to infer the most probable spin axis orientation: retrograde rotation and obliquity of about 145 degrees. The strongest activity occurs about 10 minutes after the Sun culmination. The ejection velocity of grains of 40 micron diameter is about 5 m/s, much lower than the probable gas escaping velocity, thus suggesting a strong deceleration due to the nucleus gravity. The correlation between nucleus rotation and coma shape leads us to exclude significant orbital escaping from a possible bound coma close to the nucleus surface (Meech and Belton 1990). The mass loss rate is much higher than the estimate of Luu and Jewitt (1990), reaching about 20 kg/s between 1987 and 1990, and is dominated by grains of 0.1 mm size, as confirmed by the time averaged size distribution, the power index of which is -3.2 for diameters between 1 micron and 1 mm. As in the case of comet P/Schwassmann-Wachmann 1 (Fulle 1992), the persistent coma of Chiron has no memory of the outbursts observed by means of coma photometry. These bursts are dominated by micron sized grains which are ejected at high velocities and therefore leave the coma in short times, further dragged out by solar radiation pressure.

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On the Brightness of the Comet P/Halley in the Past.

Š.Gajdoš

The article deals with behaviour of a brightness of comet the P/Halley in the past. 30 confirmed apparitions of the comet, since 239 B.C., are analysed in this paper. From Sun - Earth - comet configurations in the moment of perihelion passages it can be determined several groups of individual apparition with very similar geometry. These groups were analysed with emphasis to examining of development of brightness of the comet on different long time scale.

GAS–DUST INTERACTION IN COMET SIMULATION EXPERIMENTS

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The comet simulation experiment KOSI-9 was performed in Dec. 1990. It was intended to study processes which could occur on a cometary nucleus resulting from variable irradiation by light. According to observations of comets from the Earth the build up of a dust mantle and its increase respectivly decrease in thickness was expected in coincidence with the varying insolation. A sample was placed in a vacuum chamber at a pressure of 10^{-6} mbar and consisted of 90% (by weight) water ice and 10% olivine grains (max. grain size = 10 μm). It has been insolated repeatedly at variable intensities ranging from 200 to 1900 W/m^2 (1.4 solar constants). During the first insolation cycle at highest irradiation levels strong gas, ice and dust particle emissions were observed. The rapid growth of a dust mantle was deduced from the measured suface temperatures of up to 350 K, while the sublimation temperature of water ice was 210 K. During the second insolation period when the H_2O gas flux had reached a critical value of a few 10^{21} molecules m^{-2} s^{-1}, avalanches within the mantle material occured on the inclined sample surface. The mantle broke up locally, and opened up a fresh icy surface. The trajectories of the emitted ice/dust particles are detected by a video camera and their ice content was determined by an ice particle detector. These data were compared with a model for the particle trajectories to better unterstand the coupling mechanism of ice/dust particles in a molecular gas flow.

Surface Polarimetry of Comet Tanaka-Machholz 1992d using a novel double Wollaston prism

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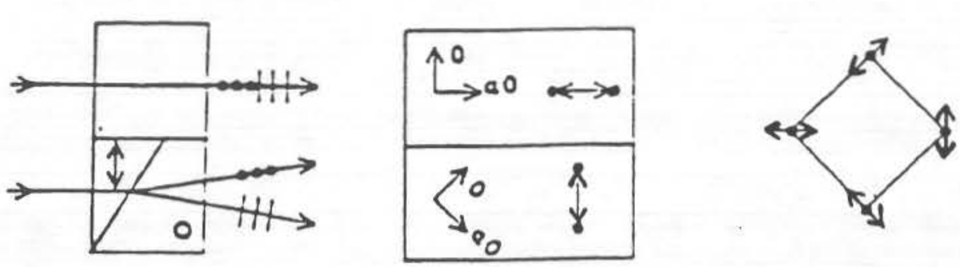
Surface polarimetry, when done with a Wollaston prism, usually requires at least two separate exposures, and it is necessary to rotate the instrument between these exposures by 45°. With comets, this technique has the disadvantage that, because of the proper motion of the comet, the background star field will change between the exposures. Also there may be temporal changes either in the sky or within the comet between exposures. In this paper we describe a double Wollaston prism which splits the exit pupil of a focal reducer and this way simultaneously produces four images with polarization directions 0°, 90°, 45°, and 135°, from which the linear polarization vector can be derived. The combination of Wollaston prisms is shown in the Figure, panel A and B. Panel C illustrates the arrangement of the four images generated on the detector. Naturally, the exposure time must be increased by a factor of two, i.e. there is no gain in efficiency, except for the saved time necessary to rotate the instrument by 45°. To avoid image overlap a mask can be put into the Cassegrain focal plane.
As a first object we observed comet Tanaka-Machholz 1992d with this instrument. The paper will be concerned with the results of these observations and will critically discuss the new technique.

Double calcite Wollaston prism

A B C



Side view Top view Image arrangement

POLE COORDINATES OF THE ASTEROID 338 BUDROSA: IMPLICATION FOR THE ASTEROIDAL FAMILY 124

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ABSTRACT

Using two standard methods we found that the possible north poles of the asteroid 338 Budrosa are (152°;+24°) and (321°;+33°). The result for this member of Family 124 agrees very well with the pole coordinates of the biggest asteroid in the Family, 349 Dembowska, and if we consider the agreement in their rotational periods, we have an important point to confirm the physical reality of this family using a collisional scenario.

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Polarization of asteroids
Synthetic curves and characteristic parameters

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New asteroidal polarimetric measurements have been performed at various phase angles for asteroids Toro, 1992 AC, Vesta and Egeria with the Pic du Midi 2 meters telescope. These data points, together with those already found in the literature, have been used to draw synthetic polarization curves for different asteroids.

The data corresponding to asteroids of the same taxonomic types are comparable. Some preliminary trigonometric fits already allow us to estimate and compare the characteristic parameters of the polarization curves (inversion angle α_0, slope at inversion h, minimum of polarization P_{min} at phase angle α_{min}) for the different types and to determine the taxonomic type of newly observed asteroids.

Dust distribution in comets
Comparison between models and in-situ data

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A three-dimensional mathematical model with an r^{-2} (where r is the nucleus distance) dust spatial distribution has been used to estimate the distance of the closest approach for the Giotto/Grigg-Skjellerup flyby. The dust brightness profiles obtained by the OPE experiment on the dark side of the coma were indeed found to nearly obey a r^{-1} law (see Le Duin et al., this Symposium). It is concluded that the nucleus distance was of the order of 200 km and that the nucleus was in the vicinity of the plane scanned by the line of sight.

Another physical model including fountain effect and fragmentation has been found to be reasonably well fitted with the results obtained by the three-channel spectrometer TKS on board the Vega/Halley mission, and to explain the color effect. It is now tentatively compared with the OPE dust brightness profiles obtained on the sunny side.

Some remarks on the radial velocities in the head of Comet West 1976 VI.

by S.Grudzińska

A spectre of Comet West 1976 VI was obtained by Herbig on 15.03.1976 with the 3m telescope of Lick Observatory. The dispersion was 11 A/mm and the radial velocity of the Comet +21 km/sec. In the region from 623.7 to 636.2 μm the emission lines - mostly from NH_2 - were measured in 4 different positions on the comets head: in the cener, at the distance of ~500 km from the center in the directions to the Sun and in the tail, and at the distance ~900 km in the tail. For those distances the difference in the radial velocity between that of the Comet was determined.The results were compared with the fountain model of cometary head calculated for the physical conditions of Comet West.

DUST MEASUREMENTS IN THE OUTER SOLAR SYSTEM

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Remote observations of zodiacal light and in-situ detection of micrometeoroids provide information on the spatial distribution of interplanetary dust, its dynamical properties, sources and sinks. Pioneers 10 and 11, Galileo and Ulysses spaceprobes took measurements of interplanetary dust from 0.7 to 18 AU distance from the sun. Distinctly different populations of dust particles exist in the inner and outer solar system. In the inner solar system, out to about 3 AU, zodiacal dust particles are recognized by their scattered light, their thermal emission and by in-situ detection from spaceprobes. These particles orbit the sun on low inclination ($i \leq 30$ deg.) and moderate eccentricity ($e \leq 0.6$) orbits. Their spatial density falls off with approximately the inverse of the solar distance. Dust particles on high inclination or even retrograde orbits dominate the dust population outside about 4 AU. The dust detector onboard the Ulysses spaceprobe identified interstellar dust sweeping through the outer solar system on hyperbolic trajectories. Within about 1 AU from Jupiter Ulysses discovered periodic streams of dust particles originating from within the jovian system.

ON THE COMMON NATURE AND THEORY OF THE QUANTUM PHENOMENA IN COSMIC AND ATOMIC PLANETARY SYSTEMS

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A spacial restriction of the mentioned planetary systems (PS) with the non-poin Newton's (Coulomb's) law attracting centre in combination with the laws of energy and cinetic momentum conservation of the moving in central force fields bodies are natural selection base of permanent satellites. Interaction of permanent satellites,which are circulating around the centre on the osculating elliptic orbits, are tend to the formation of the discrete spherical systems (in the case of the plane system they are tend to the annular structures) of the type of standing waves in the medium of substance size fractions. On the basis of classical mechanics principles and laws it is obtained the universal for the cosmic and atomic PS equation $\Delta\psi - 4mh^{-2}(E - \Pi)\psi = 0$, which is identic to the stationary Schrodinger equation, but in contrast to the latter this equation, its parameters and its solution are interpreted in obvious terms of classical physics. The solution of this equation had permited to predict (1964) unknown before regularities in the solar system, which were confirmed by the groundbased and cosmic observations qualitatively and quantitatively. This interpretation opens big possibilities not only for understanding of the "hazy, pecular, unlike our ordinary experience atomic behaviours", but also for further investigations and solutions of the problems, that even formulation has some difficulties with the present quantum-mechanics interpretation. This report is accompanied by the mathematical expressions and slides.

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SIGNS OF MACROQUANTUM PHENOMENA IN THE DISTRIBUTION OF METEORIC MATTER AND NEAR-EARTH ASTEROIDS

Yu. K. Gulak, T. N. Nazarova (Gravimetrical Observatory of the Ukrainian Academy of Sciences, Institute of Geochemistry of the Russian Academy of Sciences)

Cosmic investigations as well as grounbased observations confirm the predicted formation of the dusty belts in the system of Sun (SS) by formula $a_n = na_0/2$. As single Goldreich's shepherds there are asteroidal belts, from which meteoric matter is sweeped into the interannular gaps by the perturbing actions of regularly moving collective shepherds [1]. The particles, that escaped capture into the gaps go into space adding to the part of meteoric matter, which we observe as sporadic meteors. Owing to the laws of conservation of the specific whole energy and angular momentum in gravitational field of SS, the every sporadic meteor bears an information about the latest act, which perturbed the movement of as meteor observing particle. This is the reason why the peaks corresponding to those distances from the Sun, where the asteroidal belts situated, i.e. $a_n = na_0/2$ [2,3], should be observed against a background of total trend of the continued spectrum of fixing on the Earth sporadic meteors speed-energies. Such regularity was found in the distribution of hundred thousands of sporadic meteors [4]. The annotating report contains both wide theoretical basis and data on registration of meteor particles by the spacecrafts "Mars" and "Venera" (T. N. Nazarova) and on grounbased observations of the discovered by A. K. Terentyeva meteor-eccentrides family [5]. The way of analysis of this data is also described in this report. The results are shown at corresponding tables.

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DISTRIBUTION OF THE GRAVITATING MATTER IN THE SYSTEM OF SUN AS CONSEQUENCE OF MACROQUANTUM PHENOMENA

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The Solar System (SS) is the pattern of the spacially restricted ($r < r_g$) Planetary System (PS) with non-point attracting centre ($r > r_o$). Plenty of different-fraction bodies that can be observed are moving within PS. Their masses differ up till 40 orders. As a whole SS is stable enough, it's permanent satellites are circling on the osculating ellipses. The latter are within the Effective Acting Zone (EAZ) of the centre ($r_g < r < r_o$). The mutual perturbing movements of the permanent satellites on the arbitrarily placed osculating ellipses are radial, azimuthal and latitudal oscillations within restricted EAZ. Thus, a stable structures 'of the type of standing waves must be formed and observed in SS and displayed in the space of elements osculating orbits a, e, i, etc. as alternating discrete clusters and rarefactions. As semi-major axis a, eccentricity e, and inclination i define specific whole energy, angular momentum, and spacial orbit orientation, so the distribution of these values should have quantum character. In according to solution of the fundamental equation of the universal quantum theory of the cosmic and atomic PS, which is submited in the Gulak's report on this conference, the length of modes (standing waves) must be commensurable. In particular radii a_n of ring middles of the corresponding dimension fractions must be in accordance with the formula $a_n = na_o/2$, where a_o - commensurable linear element, n=2, 3, 4, ... - natural numbers.

This report submits: methods of search of predicted regularities and its confirmed graphs, tables, two-dimensional diagrams. Authors are grateful to V.I.Eremin and N.V. Tverdokhvalova for software support of this work.

Optical and Physical Properties of Comet Dust Models; Numerical and Laboratory Results

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Clusters generated by ballistic spheres condensing on a nucleus, the Vold-Sutherland model, are known to generate tenuous structures of apparently fractal dimension. Even sparser structures, that may be relevant to comet dust and meteoroids, are formed by using small clusters of spheres as building blocks to generate balistic aggregates. In our models, each set of two to four spheres represents individual interstellar grains that may have aggregated to form comets. Larger building blocks are used to simulate a possible precometary stage of aggregation in the presolar nebula.

We calculate optical properties of the aggregates consisting of up to a few hundred unit spheres using three separate implementations of the Discrete Dipole Approximation. The numerical results are compared with precise microwave analog measurements to illustrate the advantages and disadvantages of each implementation.

We also calculated the mean free path of a gas molecule inside the clusters for use in modeling of physical stress and in thermal modeling of cometary meteoroid material under a variety of conditions including atmospheric entry. The calculations may also be relevant to some modeling of gas diffusion in comet nuclei. The mean free path l_m is a function of the packing factor p and the unit particle radii r. We find that l_m may be approximated by 1. The diffusion coefficient may be approximated by$D \approx \sqrt{\pi kT/72mD_o(p^{-1}-1)}$ where $D_o \approx 2$ and the exact value depends on the detailed structure.

Synthetic curves for polarization of comets

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Synthetic curves of the evolution of the polarization degree with phase angle have been derived from all available cometary polarimetric data. These curves, presented for different wavelengths in the visible domain, are relevant of the nature of the cometary comae.

The curves have been previously fitted by a third order polynomial (Levasseur-Regourd et al., ACM '91). A new approach uses a trigonometric fit to derive the main parameters of the curves (inversion angle α_0 and slope at inversion h; minimum of polarization P_{min} at phase angle α_{min}; maximum of polarization P_{max} at phase angle α_{max}). In the red domain (670±50 nm), these characteristic parameters are typically found to be of the order of:

α_0 (°)	h (10^{-2} deg^{-1})	α_{min} (°)	P_{min} (per cent)	α_{max} (°)	P_{max} (per cent)
23 ±1	0.25 ±0.05	11 ±3	-1.5 ±0.5	90 ±15	16 to 26

There is a good agreement between all polarimetric values at small phase angles, while the dispersion at large phase angles could be an indicator of differences in the activity of comets.

AVERAGED HAMILTONIANS AT THE 2:1 AND 3:1 RESONANCES OF THE ASTEROID PROBLEM, VALID GLOBALLY

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Abstract: The method of averaging is a very useful tool in the study of resonant asteroid motion. The averaged Hamiltonian is expressed in the form of a power series in a small parameter (the eccentricity of the asteroid), and one can obtain in this way quite simple expressions. However, these Hamiltonians are valid for small values of the parameter only and therefore are not very useful for a complete understanding of the evolution of the asteroid. More elaborate methods have been developed by several investigators, who obtained averaged Hamiltonians valid for all values of the eccentricity, but these latter expressions are very complicated and not readily expressible in elementary functions. In the present study we propose a novel method to obtain a realistic model for the averaged Hamiltonian near a resonance, which is very simple and is valid globally. The main idea is to transform the simple averaged Hamiltonian, which is originally valid for small values of the eccentricity, to a new Hamiltonian by adding a *correction term*. The criterion is that the *corrected* Hamiltonian must have the same fixed points with the correct stability indices as the real model (in this case the *elliptic restricted three body problem*). Since the fixed points of the averaged Hamiltonian correspond to the periodic orbits of the real model, a detailed knowledge of the families of periodic orbits of the elliptic restricted problem near the main resonances is essential.

The corrected model obtained in this way represents a dynamical system which is similar to the real one, in the sense that the topology of its phase spase is the same as that of the real system (obtained by the method of *Poincaré* mapping on a suitable surface of section). Thus, the evolution of the asteroid obtained by the above model should be essentially the same as that of the real system, since similar dynamical systems have the same generic properties.

In the present study we have applied the above method to two main resonances in the asteroid belt, the 2:1 and the 3:1 resonance. The model obtained includes in both cases all the high eccentricity resonances (that are missing in the simple expression). The model for the 2:1 resonance also includes the high instability near the collision at the eccentricty $e = 0.6$ and the fine structure of interchange from stability to instability near collision. The evolution of the asteroid, as obtained by the *corrected Hamiltonian* compares very well with similar studies carried out by different methods.

By the above described technique we can obtain *simple* and *realistic* models for the averaged Hamiltonian near any other resonance in the asteroid problem.

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The Bologna - Modra forward scatter radar experiment: Reflection properties of meteor trains

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Observational results on the reflection properties of meteor trains obtained by a forward scatter bistatic radar over the baseline Bologna - Modra (about 700 km) in 1992-1993 are presented.

The observations, carried out during the activity of meteor showers with the different geometric conditions allow to deduce the dependence of the received signal amplitude and the meteor echo rates on the motion of the radiant of a meteor shower. It is shown that the forward-scatter operation may significantly contribute to the knowledge of meteor train properties and may be used for the determination of physical properties of the meteoroid particles.

10 μm Spectra of Comets and the Composition of Silicate Grains

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A 10 μm emission feature is seen in filter photometry of many comets, but high signal/noise spectra exist for only a few. Spectra of Bradfield 1987 XXIX, Levy 1990 XX, both long period comets, and P/Halley show a strong, double–peaked emission feature with maxima at 9.8 μm and 11.25 μm. They differ by ~0.4 μm in their width and 8–9 μm rise. No single silicate mineral can account for the observed emission feature. Mg–rich olivine (forsterite) matches the 11.25μm peak, while enstatite and amorphous olivine have maxima at 9.8 μm. To fit the 8–9 μm rise, amorphous enstatite, amorphus anorthite, or hydrated silicates are possible. Based on the spectra, data from the Halley flybys, and chondritic aggregate IDPs, a mix of Mg–rich olivine and pyroxenes seems the most likely composition of the silicates.

The new comets Wilson 1987 VII, OLR 1989 XIX, and Austin 1990 V each have a unique spectrum that differs from those above, implying differences in the composition of the silicates.

This research was carried out in part at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA.

EMPIRICAL MODELS OF ASTEROID PHASE RELATIONS

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The empirical magnitude model currently in use, the H-G system, is based on the premise that the phase curve of any asteroid, $\Phi(\alpha)$, can be represented, in intensity units, as the linear sum of two intensity functions, $\Phi_1(\alpha)$ and $\Phi_2(\alpha)$:

$$\Phi(\alpha) = a_1\Phi_1(\alpha) + a_2\Phi_2(\alpha),$$

where a_1 and a_2 are constants for a given object. In magnitude units, we have:

$$V(\alpha) = -2.5 \log[a_1\Phi_1(\alpha) + a_2\Phi_2(\alpha)] = H - 2.5 \log[(1-G)\Phi_1(\alpha) + G\Phi_2(\alpha)],$$

where the second form is the H-G phase relation, with H and G defined as follows:

$$H = -2.5 \log(a_1 + a_2) \qquad G = a_2/(a_1 + a_2).$$

In this form, the two reference functions, $\Phi_1(\alpha)$ and $\Phi_2(\alpha)$, are normalized to be equal to 1.0 at zero phase angle. Underlying this formalism is the hypothesis that singly scattered and multiply scattered components of the returned light from any surface obey the same phase relations respectively, and that all that differs among phase curves of actual objects is the ratio of one component to the other. While we had in mind singly and multiply scattered light for $\Phi_1(\alpha)$ and $\Phi_2(\alpha)$, the linear relations are equally valid for any arbitrarily defined functions which are themselves a linear combination of $\Phi_1(\alpha)$ and $\Phi_2(\alpha)$. Thus we can take for our reference functions two *observed* phase relations of actual asteroids, and attempt to use them to fit other asteroid phase data. We have done this using for $\Phi_1(\alpha)$ and $\Phi_2(\alpha)$ smooth curves drawn through the data three very well-sampled phase curves of low, medium, and high albedo asteroids: 47 Aglaja, $p_V = 0.072$; 113 Amalthea, $p_V = 0.27$; 44 Nysa, $p_V = 0.49$. Initial attempts, using various pairs of the three curves, have been discouraging, probably because they are in fact the set of curves which clearly demonstrate the invalidity of the H-G hypothesis. Indeed, when any two are used to try to fit the data of the third object, the fit is poor.

The above formalism suggests a logical extension of the H-G system to three or more parameters. One could consider the phase relation of an object to consist of the linear sum of three (or more) components:

$$\Phi(\alpha) = a_1\Phi_1(\alpha) + a_2\Phi_2(\alpha) + a_3\Phi_3(\alpha).$$

Since we already conveniently have three precisely defined empirical functions, we can try fitting other phase data to a system of all three intensity functions. I have made some preliminary investigations of this, and found that for most data sets covering a limited phase angle range, the three-parameter fit is good, but unstable because the three functions are so highly correlated over limited phase ranges. What the exercise has demonstrated is that it is not possible to predict magnitudes far outside the range of observation, because of this high correlation.

Another variation is to consider linear sums in magnitude space, i.e.:

$$V(\alpha) = H + a_1V_1(\alpha) + a_2V_2(\alpha) + \ldots\ldots$$

where $V_1(\alpha)$, $V_2(\alpha)$,..... are the same (empirical) functions as $\Phi_1(\alpha)$, $\Phi_2(\alpha)$,....., but in magnitude units rather than intensity units, that is, $V_i(\alpha) = -2.5 \log[\Phi_i(\alpha)]$. Since $V_1(0) = V_2(0) = 0$, a_1 and a_2 are independent of H, so the system can be a three-parameter system (4 parameters for a 3-function system); or one can impose the constraint that $a_1 + a_2 = 1$ reducing the system by one parameter, but it is not fundamentally required. Some of these variations have also been investigated in a preliminary way, using both two and three function versions of the above formulation. Results of these fits for a number of well sampled asteroid phase curves will be presented.

The Relationship Between the Semi-Major Axis and the Mass of Perseid Meteoroids

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Meteoroid streams are produced by decaying comets. The cometary ices are sublimated by the absorbed solar radiation and momentum transfer from the resulting flux of gas pushes loosely bound meteoroid dust away from the cometary nucleus. The meteoroid ejection velocity is a function of, among other things, the inverse square root of the effective radius of the dust particle. Hence the width of the resulting meteoroid stream and concomitantly the stream orbital semi-major axis distribution should vary as a function of the mass of the meteoroids. An investigation of this function has been carried out using photographic Perseid stream meteoroids, of which there are an abundance of in meteoroid orbit catalogues. We expect the Poynting-Robertson effect to have only a limited influence on the orbital parameters of the meteoroids being considered, as their estimated masses are in excess of 0.001 g. Both parent comet (P/Swift-Tuttle) and stream have high orbital inclinations so it is also expected that neither have suffered much from gravitational perturbations due to the major jovian planets.

It is shown that the most massive meteoroids are concentrated at the central core of the stream with the meteoroids of lesser masses having a much more diffuse distribution of orbits. This is consistent with the meteoroid emission velocity from the cometary nucleus decreasing with mass. This finding is confirmed by the fact that plots of meteoroid mass as a function of semi-major axis show that, on the whole, the spread in the distribution of meteoroid orbital semi-major axis decreases with meteoroid mass. There is, however, one complication. The spread in the semi-major axis distribution becomes narrower for meteoroids in the mass range $1 > m > 0.1$ g. Further investigation using Geminid meteoroids reveals that this is not a unique characteristic.

The general Perseid meteoroid semi-major axis distribution is modelled using a simple meteoroid ejection function. It is shown that the observed distribution cannot be easily reproduced using the 'Whipple Formula' because meteoroid ejection velocities predicted by that Formula are too small. The 'Whipple Formula' does, however, produce a curve of relative ejection velocity as a function of mass which has a similar form to the observed curve of orbital semi-major axis as a function of mass.

How pristine is a cometary nucleus ?

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ABSTRACT

We have studied thermal history of cometary nuclei during residence in the Oort cloud, using the low thermal conductivity of amorphous ice recently obtained by Kouchi et al.(1992). Since a cometary nucleus is a porous aggregate of grains with an individual grain being composed of a refractory core and an icy mantle, the bulk thermal conductivity of a cometary nucleus is assumed to be expressed by the product of the thermal conductivity of individual grains and a reduction factor resulting from the porous structure of the nucleus. The initial state of H_2O ice is assumed to be amorphous.

The results show that, before crystallization from amorphous ice to crystalline ice occurred, the bulk thermal conductivity of comets was very low and the nucleus was effectively heated up by radioactive nuclides ^{40}K, ^{232}Th, ^{235}U, and ^{238}U with the chondritic abundances. It is shown that the thermal histories are clearly classified into two distinct types depending mainly on the nucleus thermal conductivity κ: 1) The comets of small κ experience internal temperature higher than 125 K during residence in the Oort cloud, and the most of the ice in the nucleus crystallizes. 2) For the comets of sufficiently large κ, on the other hand, the temperature does not become high (< 100 K) so that the initial amorphous ice is almost completely preserved. These results imply that the ice in Halley-sized comets of about 5 km radius crystallized during the residence in the Oort cloud.

For the case of 2), we present analytic expressions of a maximum temperature $T_{\rm max}$ and the total fraction of crystallization $\xi_{\rm max}$ on the basis of the analysis of the physical processes of the crystallization. In most cases, $T_{\rm max}$ is around 80 K, implying that CO or CO_2 trapped in H_2O ice is preserved.

A criterion of the crystallization is derived in an analytic expression, which makes it possible to examine the dependence on the physical quantities relevant to the crystallization. Discussion is given on the properties of comets that preserve pristine amorphous ice.

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(4015) 1979 VA: "Missing Link" Discovered

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Apollo Asteroid (4015) 1979 VA was discovered in November of 1979 by Helin at Palomar with the 0.46m Schmidt Telescope. Its' orbital elements immediately indicated a possible cometary origin. With an extremely eccentric orbit, it approaches the orbit of Jupiter (at the time, the largest "Q", aphelion, of any known near-Earth asteroid). Physical observations acquired during the discovery apparition suggested that it was carbonaceous in nature.

Research into prediscovery observations of Near-Earth Asteroids (Bowell et. al., 1992) has located Palomar Sky Survey photographic plates taken in 1949 observations of (4015) 1979 VA, not as an asteroid, but rather a small cometary image (IAU Circular Nos. 5585 and 5586, August 13, 1992). In 30 years, we have witnessed photographically, the physical transition of a comet to an asteroid.

(4015) 1979 VA was observed last year in order to see if any cometary activity was present during this approach to perihelion. No obvious activity was detected from ground based telescopes. As mentioned earlier, the observations from 1949 show the object as an asteroidal like image, but with a small tail. In 1979, when discovered as a bright asteroid, it showed no apparent coma or tail. Curiously, however, there were some unexplainable irregularities in the data. Review of this data leads to the theory that it may have been degassing intermittently (Harris, personal communication). Review of the large amount of data is now underway to better understand this tantalizing object.

As a consequence of identifying (4015) 1979 VA as a former comet, it has become a priority small body target for a Discovery Mission. The selection of (4015), a defunct comet, is an exciting target considering its recent evolution into an asteroid. NASA and ESA are both considering missions to (4015). This evidence of the generic relationship between comets and asteroids has been long-awaited.

This research was conducted at the Jet Propulsion Laboratory and at Palomar Observatory, California Institute of Technology, under contract with the National Aeronautics and Space Administration (NASA).

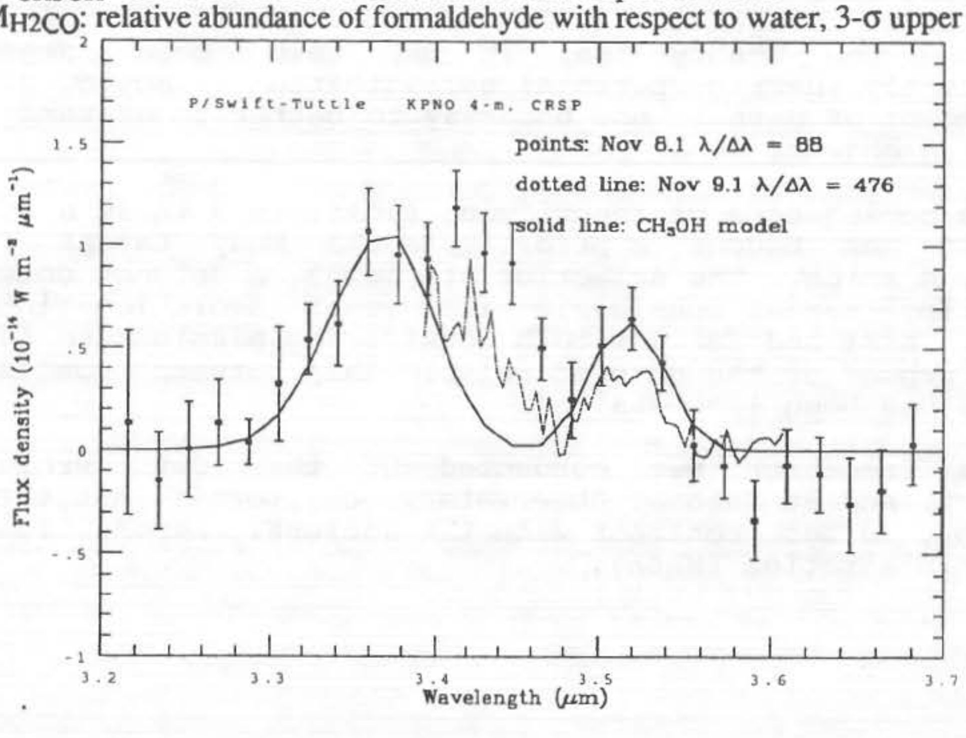
Infrared Measurements of Methanol in Comet P/Swift-Tuttle

Susan Hoban (USRA), Dennis C. Reuter , Michael J. Mumma (NASA/GSFC), and Michael A. DiSanti (NAS/NRC),

Using the **CR**yogenic **SP**ectrometer at the Kitt Peak National Observatory, we obtained infrared spectroscopic measurements of fluorescent emission from methanol in comet P/Swift-Tuttle on 1992 November 8, 9 and 12 and December 8 and 10. We retrieve production rates of methanol from the ν_3 band at 3.52 μm for each night (see Table). We find our results to be consistent with values reported by Paubert *et al.* (1992, IAU Circ. No. 5664) from measurements of methanol with the IRAM millimeter telescope, and with infrared spectroscopic measurements with CGS4 on the UKIRT (Davies *et al.* 1992, IAU Circ. No 5659). For the lower resolution spectrum from Nov 8, we are able to extend the model to the ν_2 and ν_9 bands near 3.4 μm, and we find that methanol contributes a significant fraction of 3.4-μm "cometary organic feature" in this comet. An example of the $\lambda/\Delta\lambda = 88$ measurements from Nov 8.1, the $\lambda/\Delta\lambda = 476$ measurements from Nov. 9.1, and the methanol model are shown in the figure below. We find the relative abundance of methanol with respect to water (mixing ratio) to be 8 ± 3 %. There may be weak evidence for temporal variability in the methanol mixing ratio; however, we have insuffcent data to determine if there exists a correlation with rotational phase. Formaldehyde was not detected; 3-σ upper limits are given in the table.

UT date (1992)	Q_{CH_3OH} (10^{28} s^{-1})	M[a] (%)	Q_{H_2CO} (10^{27} s^{-1})	M[b] (%)
Nov 8.058	2.9 ± 0.7	12 ± 5	< 6.0	< 2.4
Nov 9.066	2.0 ± 0.5	8 ± 3	< 0.4	< 0.2
Nov 12.102	4.2 ± 1.9	14 ± 7	< 1.8	< 0.6
Dec 8.076	6.0 ± 1.6	9 ± 4	< 1.7	< 0.3
Dec 10.069	3.1 ± 1.0	5 ± 2	< 3.1	< 0.5

[a] M_{CH3OH}: relative abundance of methanol with respect to water
[b]M_{H2CO}: relative abundance of formaldehyde with respect to water, 3-σ upper limits



A Neural Network Asteroid Classification Based on Water of Hydration

E. S. Howell, E. Merényi, and L. A. Lebofsky, (LPL, U. Arizona)

The hydration state of surface minerals has proven to be an extremely useful tracer of an asteroid's thermal history (Jones *et al.*, 1990, *Icarus* **88**, and Lebofsky *et al.*, 1990, *Icarus* **83**). The distribution of hydrated minerals is a probe of the metamorphic history of the asteroid belt, since the alteration process producing hydrated minerals requires the presence of liquid water. Over the last five years, we have obtained extensive asteroid observations in the 3-μm spectral region to detect the presence of water. The strong absorption band at 3μm due to hydrated minerals is not easily masked even by abundant opaque materials on low albedo objects. Using this compositional information, we have obtained a cluster structure of those asteroids for which data on the surface hydration state is available. The technique for cluster structure determination is a Kohonen-type self-organizing neural network. Previously, we have used this technique successfully to extend the Tholen asteroid taxonomy (Tholen, 1984, PhD Dissertation), by increasing the spectral range from the visible (0.3–1.1 μm) to the near-infrared (0.3–2.5 μm). Now, we increase that spectral window further to include the hydration feature at 3 μm. With this additional compositional information, we hope to clarify the relationship between taxonomic classes and asteroid surface composition in an attempt to better understand the true compositional distribution of the asteroids. Although the Tholen taxonomy has proven extremely valuable as a guide to compositional distribution, there are many examples of compositional diversity within asteroid classes. The S-type asteroids show a large range of pyroxene and olivine compositions and relative abundances (Howell *et al.*, 1993, in press, and Gaffey *et al.*, 1993, *Icarus*, submitted). Among the C-type asteroids observed to date only about half are hydrated (Jones *et al.*, 1990). Based on their featureless, red-sloped spectra and moderately high albedo (A=0.15–0.25), M-type asteroids have been associated with Fe-Ni metal. However at least two of these objects show water of hydration, inconsistent with an Fe-Ni composition. E-type asteroids show a spectral similarity with the enstatite achondrites or aubrites, but E-type asteroid 44 Nysa shows a hydration band, inconsistent with this composition. Thus, we see a large degree of compositional diversity within these taxonomic classes which are spectrally uniform in visible and sometimes even near-infrared spectral ranges. Extending the spectral range coverage for a larger sample of asteroids will allow us to develop a more compositionally meaningful taxonomy. We can then more fully explore the compositional diversity and spatial distribution of the asteroids.

GAS AND DUST VELOCITIES IN COMETS DETERMINED FROM A DUSTY COMA MODEL

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Multifluid, hydrodynamic simulations for the gas, dust, and plasma flow appropriate for the spacecraft encounters with comets P/Halley, P/Giacobini-Zinner, and P/Grigg-Skjellerup allow a comparitive study of how features of cometary comae scale with gas production (Q) and dust-to-gas mass ratio (χ). The simulations are based on a spherically symmetric, neutral coma model with detailed photo and gas-phase chemistry and dust entrainment by the gas. The model includes a separate energy balance for the electrons, separate flow of the neutral gas, fast neutral atomic and molecular hydrogen, dust size distributions with fragmentation, distributed coma sources of gas-phase species related to the dust, and a smooth transition to free molecular flow in the outer coma.

These simulations show that the terminal gas velocity is constant at about 1 km s^{-1} for gas production rates less than approximately 10^{29} molecules s^{-1}. At higher gas production rates, the terminal gas velocity steadily increases to about 2 km s^{-1} at $Q \approx 2{\cdot}10^{30}$ molecules s^{-1}. This behavior is caused by the photodissociation of water coupled to the extent of the collision zone in the inner coma. It is consistent with water velocities determined from OH observations and the *in situ* measurements of the gas velocity of P/Halley by the Giotto NMS instrument. The terminal dust velocities for sizes less than about 10 μm appear to follow a similar relation with an increase beginning at about $Q = 4{\cdot}10^{28}$ molecules s^{-1}. In comparison with observations, the model can be used to deduce gas and dust velocity laws within the coma.

SEARCH FOR PLASMA PRODUCTION MECHANISMS IN SPACE OBJECTS: COMETS AND ASTEROIDS

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Space plasma being a mixture of neutral and excited atoms, ions, electrons and photons is the necessary onset for the possibility of studying celestial bodies by both in situ measurements during space missions and space-borne /ground-based observations. In the light of this conception production of a plasma due to impacts of interplanetary/ circumsolar dust particles with gaseous and dusty components of comets is investigated. The efficiencies of the two ionizing mechanisms are found and compared.

Calculations show that in regions where the density of interplanetary dusty matter $\rho \gtrsim 10^{-21}$ g/cm^3 at comet heliocentric distances R$\lesssim$1AU the ionization rate of circumnuclear region of dusty cometary atmospheres due to impacts of cometary and zodiacal dust particles may exceed the rate of ionization of cometary molecules by solar short-wave radiation.

Grain-grain collisions are essential plasma and radiation generating process for both dusty comets of a Halley 1986 III type and asteroids.

MIGRATION OF BODIES TO EARTH. S. I. Ipatov, Keldysh Institute of Applied Mathematics, Moscow, Russia

It is believed that bodies can migrate to the Earths orbit from the Kirkwood gaps, from the inner part of the asteroid belt, from the belts beyond Neptune, and from the Oort cloud. Our obtained results show [1,2] that even more bodies from the 5:2 Kirkwood gap might reach the Earths orbit than from the 3:1 gap. Contemporary bodies can migrate to the gaps due to the gravitational influence of the largest asteroids and due to collisions with other asteroids.

The variations in orbital elements of three gravitationally interacting objects with masses equal to that of Pluto showed that the eccentricity of one of these objects could reach 0.4 during the existence of the solar system [3]. This result indicates the possibility of migration of some bodies from the belt beyond Neptune to Neptune's orbit if the masses of the largest bodies in the belt exceed the mass of Pluto. The results of computer simulations show that more than 1 % of the bodies can reach the orbit of Earth from the region of Uranus and Neptune [4,5].

The orbital elements of Earth-crossing objects change significantly before they impact planets. The obtained results show that the average time up to the collision with Earth is equal to 10^8 years (but due to the ejection by Jupiter the lifetime of these objects may be 10 times less). The mass distribution of Earth-crossing objects may be the same as that for the main asteroid belt. The average time when some object with a diameter $d > D$ impacts Earth may be equal to $0.5 \times (D/D_\circ)^{1.8}$ where $D_\circ = 1$ m.

We have made a series of calculations of evolving disks initially consisting of planets and Mars-crossing objects. In some runs objects also were Earth- and Jupiter-crossers. The gravitational influence of planets was taken into account by the action spheres method, i.e., two two-body problems were considered. We found that some objects migrated to Jupiter, which ejected them into hyperbolic orbits, and some objects migrated inside the solar system. At the initial eccentricities $e_\circ = 0.7$ and initial semimajor axes $a_\circ = 3.1$ (the objects coming from the belt beyond Neptune) or $a_\circ = 2.82$ (the 5:2 Jovian resonance) when half of the initial objects had been ejected from the solar system, one-sixth of all initial objects were Earth-crossers but were not Jupiter-crossers. More than 1 % of all initial objects impacted Earth during evolution. The number of objects that impacted Venus and Mercury was not significantly less than that for Earth. At the last stages of disk evolution, some objects were only Mercury- and Venus-crossers. At $e_\circ = 0.5$ and $a_\circ = 1.7$ the number of objects that impacted Earth was several times larger than at $e_\circ = 0.7$. If initial objects crossed only the orbit of Mars, then the process of migration was much slower and more objects impacted Mars than Earth.

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Phobos Dust Rings

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Taking into account the gravity forces of the sun, Mars and Phobos, and solar radiation pressure forces on dust particle, we have performed the numerical calculations of orbital trajectories for dust particles ($m \geq 10^{-14}$g) ejected from Phobos based on fourth-order Runge-Kutta method. It is found that the orbital evolution of such small particles is strongly affected by solar radiation pressure forces. Their orbits differ from that of Phobos and consequently a collisional probability of these grains on highly eccentric orbits with Mars increases. On the other hand, large particles take similar orbits to that of Phobos after ejection and they will be re-captured by Phobos after short time scale. We have estimated the values of these time-scales for arbitrary mass of particles. As the result, it is found that the particles which could form dust rings for a significantly long time near the Phobos orbit have a narrow size (or mass) distribution (10^{-10}g<m<10^{-7}g). Furthermore, in the dust rings, orbital segregation of particles by their sizes or masses occurs. We have also examined a spatial density of particles in dust rings. Although the expected dust rings are very thin, a possibility to detect this ring particles by the planned dust detector on board of the Mars mission (Planet-B) of Japan in 1996 is briefly discussed.

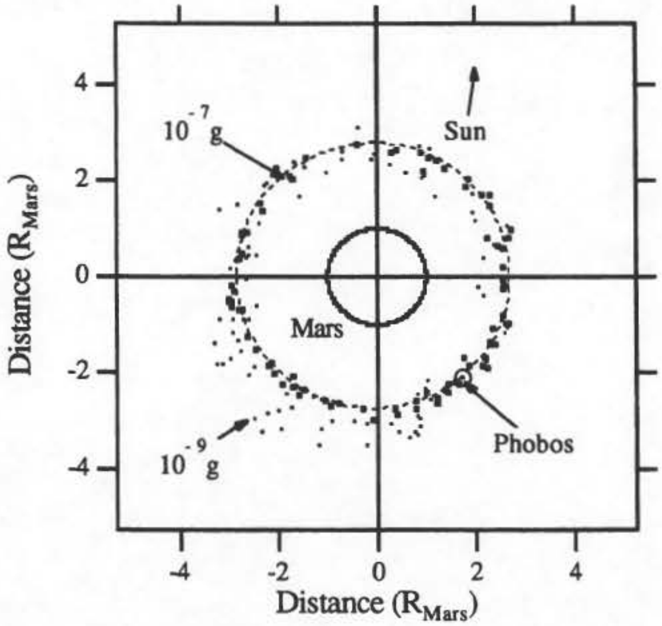

Fig.1 A spatial map of dust particles which projected on the orbital plane of Phobos after 5 years from the first ejection.

PHOTOMETRY OF COMET LEVY (1990c) AROUND 380nm. PHYSICAL PARAMETERS OF THE CN COMA

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Main results of the processing of Comet Levy's photographical observations were analyzed. The plates were taken in August 1990 with 50/70cm. Schmidt telescope through a narrowband filter. The spatial parameters of the coma of CN parent molecules are determined using two plates. According to our preliminary evaluations on one of the two plates a slight fountain effect is visible. Estimations for radial expansion velocity of CN coma are given.

AUTONOMOUS NAVIGATION AT THE SPACECRAFT FLIGHT TO THE ASTEROID

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The problem of the navigational ensuring of the spacecraft sended to the asteroid to mitigate the danger of its impact with the Earth is investigated in the paper. The most responsible flight stage is the last phase, the rendezvous of spacecraft with the asteroid. Required high accuracy of pointing the space probe to the asteroid is proposed to ensure with the help of autonomous navigation system using optical-TV sighting the planet against the star background and, perhaps, on-board radio measurements. In this case, the ground measurements have to secure bringing the spacecraft to the required neighbourhood of the asteroid, pointing the optical sensors to the planet and providing the autonomous navigation system with the initial information for determination of the spacecraft orbit relatively the asteroid.

The various schemes of spacecraft flight to the asteroid are considered: a) an impact of spacecraft with the asteroid to apply some velocity impulse to this asteroid and to change its orbit, b) a transfer of spacecraft in the orbit of the asteroid "satellite", c) soft landing spacecraft onto the asteroid surface, d) flyby of the asteroid with distant investigation of this planet.

The problem of using the navigational measurements for the determination of the physical and celestial mechanics characteristics of the asteroid, such as its mass, dimensions, density of its matter, its orbit elements, is investigated.

The keywords: asteroid hazard, asteroid missions, space navigation, autonomous navigation, optical-TV sighting.

An analysis of some methods of asteroid hazard mitigation for the Earth

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Some methods of the mitigation of asteroid hazard for the Earth using the missions to the asteroid and the control of asteroid's motion are investigated in the paper. They are: the method of the direct mechanical influence at the asteroid by the spacecraft impact and applying the velocity impulse to the asteroid; the method of the influence by the chemical engine of the high thrust brought onto planet surface; the method of the influence by the electric-jet engine of the low thrust; the method of changing asteroid's orbit with the help of a solar sail; the method of painting asteroid's surface.

The characteristics of the asteroid motion control by these methods are presented. The numerical valuations are given for the Toutatis asteroid which flew close by the Earth in December, 1992.

On the base of the approximate comparative analysis of these methods the method of the direct mechanical impact was chosen for the more detailed study.

Keywords: asteroid hazard, asteroid missions, impulse control, thrust control, solar sail control, painting control.

Cometary Implications of the Transient IR Emission Spectra of the Photofragments Formed in the Laser Photolysis and Laser-Induced Reactions of Small Molecules

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ABSTRACT

The experimental results from the transient infrared emission spectroscopy (TRIES) studies recently performed in our laboratory will be described. Vibrationally excited radicals are produced when an ArF laser is used to photolyze molecules because the photon energy of this laser is usually much greater than the bond energy of the molecules. Infrared emission can also be observed when radicals formed by laser photolysis undergo exothermic reactions with stable molecules or with each other.

To do these TRIES laboratory studies an ArF laser was combined with a Perkin-Elmer infrared monochromator, a fast infrared detector, a 2 μs transient digitizer, and an IBM compatible computer. The vibrationally excited species that have been observed using this experimental system are C_2H, C_2, CH_3, HCN, HNC, CO, C, and C_3H_3. Some of the species may also be important in cometary atmospheres. These laboratory studies suggest that the infrared emission from the inner coma may be a diagnostic for some of the chemical processes that are occurring in the coma. We will discuss how the existence of certain chemical reactions may be reflected in infrared observations of the coma that probe region near the nucleus.

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THERMAL EMISSION FROM ROTATING ASTEROIDS: EFFECTS OF SURFACE ROUGHNESS

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We calculate thermal emission from rotating asteroids at various wavelengths. The observed intensity depends on surface roughness, viewing and illumination directions and angular velocity of the asteroid. When a rough surface is heated by radiation, its temperature is not constant but varies because of shadows and varying orientation of surface normal. It is the temperature distribution visible to the detector that determines the emitted flux at that direction. Instead of using the simple relation

$$I(\lambda) = A\epsilon(\lambda, T_0)B(\lambda, T_0) \tag{1}$$

(ϵ is emissivity, B is Planck's function and A is the projected area normal to the line of sight), which holds for a surface at a uniform temperature T_0, one must use the more general relation

$$I(\lambda) = \int \mathrm{d}A(T)\epsilon(\lambda, T)B(\lambda, T), \tag{2}$$

where $\mathrm{d}A(T)$ is the differential projected area in the detector's view that is at temperature T.

The shape of the surface at mm- or larger scale is assumed to be characterized by Gaussian statistics. This yields a Gaussian distribution also for the slopes of the facets the surface is thought to consist of. We solve a diffusion equation to calculate the temperature of such facets whose normals' orientation varies, and which thus receive sunlight in different manners during the revolution of the asteroid. It is here that its angular velocity comes into play. Lunar-like material properties are assumed in the calculations. It is then calculated which of the facets are visible to the detector and what their projected area is. Radiation is assumed to be emitted as well as absorbed in proportion to the projected area, and thus the total flux in the given direction can be calculated using Eq. 2.

Ray optics is used: it is assumed that the dominating wavelengths are much smaller than the roughness scale, which must therefore be at least millimeters. Multiple scattering is approximately accounted for by using our earlier result (A & A, in press).

The results for smooth and rough surfaces are very different, especially in predictions of disk-resolved intensities. Such results as well as integrated results will be presented.

Near-Earth Resonance Structure of the Zodiacal Cloud.

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Dust particles created due to collisions in the Asteroid Belt, spiral in toward the sun due to Poynting-Robertson drag. A significant fraction of these particles are trapped in mean motion resonances outside the orbits of Earth and Venus. When the particle encounters a resonance, capture into the resonance can be treated as a probabilistic event. The probability of trapping depends on the size of the dust particle and it's orbital eccentricity, as well as the order of the resonance. Once capture occurs, the orbital eccentricity of the particle increases, eventually allowing it to escape. This phenomenon leads to a bottleneck effect in the flow of dust particles toward the sun, creating a particle number density enhancement in the Zodiacal Cloud. Preliminary results from numerical integrations yield the fraction of particles trapped in first-order resonances outside the Earth. Further analysis determines the variation of the number of trapped particles as a function of the particle size. Eventually, for a given particle size distribution the existence of any azimuthal pattern related to a given resonance is obtained. This phenomenon involves particles near the earth (that are brighter as they are closer to the sun), and is particularly important for it results in the time variability of the Zodiacal Cloud.

Search for a CO^+ tail in comet Schwassmann-Wachmann 1

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CO^+ was discovered in spectra of comet Schwassmann-Wachmann 1 by Cochran et al. (1980). Images of the CO^+ tail of comet Schwassmann-Wachmann 1 have been presented by Jockers et al. (1992a,b), but the result did not seem convincing. In a new attempt the comet was observed again with the 2m-telescope of the Bulgarian National Observatory and the focal reducer of the MPI for Aeronomy in December 1992 during opposition. A tunable Fabry-Perot interferometer with resolution of about 10 Å was employed to obtain narrow-band images of this comet in the (3–0) $^2\Pi_{3/2}$-$X^2\Sigma^+$ subband of CO^+ at 4020 Å and in a near-by continuum window at 4060 Å. Both windows are contaminated by C_3 emission, which, however, has never been observed in comet Schwassmann-Wachmann 1. Red continuum images were obtained in a Gunn R filter. For comparison with another comet, the same technique was applied to comet Shoemaker 1992y, which at that time was at a heliocentric distance of 2.54 AU and a geocentric distance of 1.80 AU. We will present the results and discuss the evidence of a CO^+ tail in both comets.

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The radiant distribution of sporadic meteors

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The radiant distribution of sporadic meteors has been determined for the ten orbital surveys catalogued by the IAU Meteor Data Center. In addition to the previously known apex, helion, antihelion and northern toroidal sources, we have discovered a southern toroidal source and have also found that the apex source appears to be split into northern and southern components. We present the characteristic for each of the sources and comments on their possible origins.

Forward-scatter determination of the radiant distribution of sporadic meteors

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We show how the observability function for meteors detected on a short-hop forward-scatter system may be calculated. Using this method we have determined the response of a specific short-hop forward-scatter system between London (Ont) and Ottawa to the diffuse sources found by Jones and Brown (1993) in the orbital the surveys catalogued in the IAU Meteor Data Centre. Using echo rate data collected continuously between 1991 and 1992 on the London-Ottawa system we have been able to determine the strengths of the sporadic meteor sources.

THE FORWARD SCATTERING OF RADIO WAVES FROM METEORS

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Abstract

We show how the WKB or phase integral method can be applied to the scattering of radio waves from overdense cylindrical trains at general incidence and present calculations for initial line densities of 10^{16} and 10^{17} electrons per metre; previous calculations over the life of the train, based on the direct numerical integration of the differential equations for the partial waves, have been limited to $10^{15}m^{-1}$. To extend results to densities greater than 10^{17} m^{-1} we consider the ray tracing method, showing that at 10^{17}electrons per metre agreement with full wave calculations is reasonable.

Recent results of forward scattering experiments show an unexpectedly high proportion of short lived echoes, one interpretation of which is in terms of head echoes. We apply the ray tracing method to a spherical cloud of ionisation in an investigation of how a forward scatter head echo might be expected to vary with time.

The dust jets of comet P/Swift-Tuttle 1992t

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The periodic comet Swift-Tuttle is known to be an "atypical" comet, producing nice and strong dust jets and fan shapes easily observable. We observed this comet on 12 evenings between November 20 and December 20, 1992 with the 1m telescope at the Pic du Midi Observatory using a CCD frame and broadband filters. During these observations, the seeing was between 0.5 and 1 arcsecond, leading to high quality images: details of less than 500 km can be seen on some of them. On the November images, a strong helicoidal dust jet rotating with time was clearly visible until a distance of 30 000 km from the nucleus, whereas another fainter jet appeared on some images until 10 000 km. The December images revealed the apparition of two new dust jets after the perihelion passage, one of them being visible in the dust tail, more than 100 000 km away from the nucleus. Due to the rotation of the nucleus, the movement of the jets is visible from hour to hour, and from one night to another. On the 9 nights of observation in November, the patterns were almost the same every three nights.
The serie of images obtained allow us to derive the parameters that describe the rotation of the nucleus: the rotation period, the orientation of the spin axis and the location of the active zones on the nucleus. We compare these parameters with those deduced by Sekanina from drawings made during the 1862 return of P/Swift-Tuttle.

Photometric study of comets P/Faye 1991 XXI and Zanotta-Brewington 1991g1

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We observed comet P/Faye 1991XXI at ESO, La Silla from July 1991 to February 1992 using IHW filters mounted on the 1m and 50cm telescopes. CCD images were also obtained at Danish 1.54m telescope on August 26, 1991 with IHW image quality filters. These data are used to study the dust production rate along the orbit, through the Afρ parameter. No gas was detected during these observations.

Comet Zanotta-Brewington 1991g1 was observed on March 31, 1992 at La Silla. Using the spectro-imager EMMI at the NTT, we got a low resolution spectrum, showing C_2 (Δv=0,1) and CN (Δv=0) bands. IHW image quality filters were used simultaneously at the Danish 1.54m telescope to get narrow-band images. We deduce C_2 and CN production rates, as well as the Afρ parameter.

Active areas on cometary nuclei

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Evidence is accumulating that the nuclei of short period comets are typically 5 km in radius, of low albedo (≈4%), and exhibit activity over only a small fraction of their surfaces. Their densities could be as low as 300 kg m^{-3} (although this parameter remains very uncertain) indicating a highly porous structure. The imaging experiments on the flyby missions to comet P/Halley revealed little or no difference in surface reflectivity between active and inactive regions. A Moon-like phase function for the surface was also derived. Active areas were around 3 km in diameter although observable features on both the inactive surface and within the active regions were typically 500 to 1000 m in dimension. The low density and high porosity suggest that up to 30 m depth of material can be lost per apparition from an active region on a comet like P/Halley. A depression such as the *Crater* on P/Halley must therefore be at least a few hundred years old (if created by sublimation). The emission from P/Halley appears not to have changed significantly since records began. These conclusions suggest that active areas are very stable over long timescales.

Fine structures in the observed dust emission (also ≈500 m in dimension) have been modelled in two different ways. They may result from variations in surface topography (craters) or from hydrodynamics interactions between gases emitted from active areas surrounding inactive areas. An alternative mechanism not yet thoroughly investigated is whether the fine structures could arise from inhomogeneous emission. On a short timescale, monitoring of the comet's activity over the three hours of the Giotto flyby showed no significant changes. Several centimetres could therefore be eroded from an active area without affecting the magnitude of the emission.

The presentation will summarise our knowledge of active areas on comets and suggest that cometary nuclei should no longer be considered as "dirty snowballs" but as "icy dirtballs".

The Swings Effects of the A-X System and v" = 1-0 Band of CO.

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We have constructed a model of the A-X system of CO in order to analyze the CO bands appearing in the ultraviolet spectra of comet P/Halley and other comets obtained with the IUE. The major bands of the A-X system occur in the 1200 - 1800 A range where the temporal variation of solar irradiance is significant. The model includes electronic, rotational, and vibrational transitions, excitations by solar ultraviolet radiation, and effects of neutral (Private communications with S. Green, 1992) and electron collisions. The solar spectrum in this spectral range shows many solar emission lines, which causes a pronounced Swings effect. Comet P/Halley was observed during a period when the solar activity was quiet. We derived fluorescence efficiencies of the bands (Private communications with H. Weaver, 1993) and estimated that the ultraviolet Swings effects are less than 20 % of the fluorescence efficiencies for most bands of the A-X system. The study of the A-X system also requires knowledge of vibrational and rotational fluorescent processes in the infrared and radio regions because the majority of CO molecules in the coma is in the ground vibrational and rotational states. The solar infrared spectrum around 5 microns, where the fundamental band of CO occurs, contains strong absorption lines of the fundamental band and hot bands of CO and its isotopes. These solar absorption lines cause a 20 % reduction of the g-factor of the fundamental band at heliocentric velocities close to 0 km/sec.

Analysis of Cometary Dust: Halley Results and Option for The Future

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Abstract

Space Missions VEGA 1+2 and GIOTTO to comet p/Halley provided the only mass-spectrometric data on cometary organics available so far. The analysis of the minor constituents on the mass spectra by Kissel and Krueger (1987) allowed a characterization of the nature of the organic material as mostly unsaturated hydrocarbons with a low fraction containing Oxygen or Nitrogen as heteroatoms. On this basis Krueger and Kissel (1989) developed a scenario for a possible role of comets in the origin of life on earth. Later a comparison with the PICCA data from on board GIOTTO allowed to estimate the average molecular weight of the refractory part of the organics to be some 150 to 250 Da.

The **C**omet **R**endezvous and **A**steroid **F**lyby (CRAF) Mission of NASA would have provided a next opportunity for in situ analysis of organic cometary material with more sophisticated instruments like a time-of-flight SIMS, a gas chromatograph, and a neutral gas mass spectrometer. This mission has, however, been cancelled in January 1992.

Since then two agencies are preparing the selection process for new space-missions: NASA and ESA. While in ESA a comet rendezvous mission ROSETTA is competing for being the third so-called 'cornerstone' of the agency, within NASA the DISCOVERY program for small mission has currently selected three cometary mission proposals for further study: One CONTOUR providing a flyby at three different comets, carrying a camera and a dust mass spectrometer, C^4 MISSION (Cometary Coma Chemical Composition) carrying a camera, and a gas chromatograph to a comet rendezvous, and SMACS even smaller crafts to asteroids and comets carrying a camera and maybe one additional instrument.

All these concept would start their hardware phase around 1998, be ready for launch in 2002 and returning data between 2005 and 2012. This is a clear indication of the big cut, cometary research had to take, when CRAF was cancelled. It is, however, encouraging that interest in comets is still alive. Supporting laboratory work should be continued, as it greatly enhances the value of the in-situ data once they become available.

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Dust Particle in the Solar Gravitational and Electromagnetic Fields

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The action of the solar electromagnetic radiation on the motion of interplanetary dust particle in the gravitational field of the Sun is discussed from the theoretical point of view. Results are presented to the second order in v/c (c – speed of light, v – orbital velocity of the particle), so also general theory of relativity is used.

Dust Particles: Solar Wind and Perturbation Equations of Celestial Mechanics

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The problem of the action of the solar wind on the motion of interplanetary dust particle is discussed in detail. Differences between the action of electromagnetic solar radiation and that of the solar wind are explained not only from the point of view of the physical nature of these phenomena but also from the point of view of dust particle's orbital evolution. The standard speed of inspiralling toward the Sun is compared with the result corresponding to the fact that solar wind particles spread out from the Sun in nonradial direction.

Meteor stream of comet Encke

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The 20,000 years long-term orbital evolution of six model dust particles ejected from the comet Encke at its perihelion is investigated. Particles with ejection velocity 10 m s^{-1} were released in these directions (two orientations for each direction): tangential to the cometary motion, normal to the comet's orbital plane and perpendicular to the preceding ones. Planetary perturbations, Pluto excluding, and the simultaneous action of the solar radiation — both electromagnetic and corpuscular — are taken into account. Simulations are done for dust particles of several sizes. Obtained dispersions in orbital elements are compared and discussed.

ASTEROID PROPER ELEMENTS: A BIG PICTURE

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Determination of the asteroid proper elements, that serve as parameters for classification of asteroids into families, has dramatically improved in the recent years both from the point of view of the accuracy of the results and of the number of objects for which they can be and have been derived. Depending on the dynamical characteristics of the different groups of asteroids (main belt, high eccentricity/inclination, resonant, etc.), different methods and theories have been used for that purpose — analytical, semianalytical and numerical. This presentation is intended to provide a review of the current status-of-the-art in the field, to emphasize the achievements and to discuss the open problems.

The theory by Milani and Knežević (1990, 1992) provides the most accurate results for the bulk of the known asteroids. It is an analytic theory, based on the truncated development of the perturbing Hamiltonian, and thus is particularly suitable for most of the main belt objects of low-to-moderate inclination and/or eccentricity. The short and the long periodic perturbations up to degree four in the first order with respect to perturbing mass and these of degree two in the second order are averaged out in this theory by means of the two canonical transformations. Theory accounts for the perturbations by all the major planets, with different levels of truncation; an iterative algorithm copes with the variable frequency problem; the software monitors the occurence of the secular resonances, switching if necessary to an adapted theory; a quality code indicates the reliability of the results. The algorithm is quite efficient and applicable for mass production of proper elements; the typical accuracy is $\simeq 10^{-3}$ or better, except close to the mean motion and secular resonances, and in the high eccentricity/inclination regions, where it is seriously deteriorated.

One of the most recent achievements in the field is the semianalytic theory by Lemaître and Morbidelli (1993), which does not use the expansion in eccentricity and inclination of the asteroid; conversely, it makes use of only linear planetary terms. All the terms proportional to e' and i' are considered as a perturbation, so that the integrable part becomes a function of the asteroid's argument of perihelion. The theory is particularly suitable for the high eccentricity/inclination objects. It provides proper elements with about the same accuracy throughout the asteroid belt, presently with an error of $\approx 3-4\times10^{-3}$ in proper eccentricity, and somewhat less in proper inclination. This theory also involves an iterative procedure, it includes some second order perturbations and could account for the effects of more planets.

Proper elements for Trojan asteroids have been computed by Milani (1993). The procedure consisted in numerical integration, under the perturbation by the four major planets, for 1 Myr, and in digital filtering and compressing of the output into a "synthetic theory". The proper modes of oscillation of the variables related to eccentricity, inclination, perihelion and node defined the proper elements; the remaining proper element is defined as the amplitude of the oscillation of the semimajor axis associated with the libration period. The stability of the proper eccentricity and inclination in the covered time span was within 2.5×10^{-3}, with only a few exceptions.

Similar numerical procedure has been used by Schubart (1991) to derive the proper parameters for Hilda group of asteroids. However, in this case the numerical integration covered much shorter time spans (10^5 *yr*, at best), and no accuracy estimates were given.

One can state, in conclusion, that the efforts to produce the asteroid proper elements of an accuracy which will enable a reliable identification of asteroid families are giving the results; we have, in many cases, already reached the required accuracy, in some more complicated cases we are very close to it, and we are now even able to tackle this problem for some asteroids for which, quite recently, this seemed to be practically impossible.

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Operational Performance Test of Sampling Tools with Cometary Analogous Material - Preparation of Rosetta Space Mission

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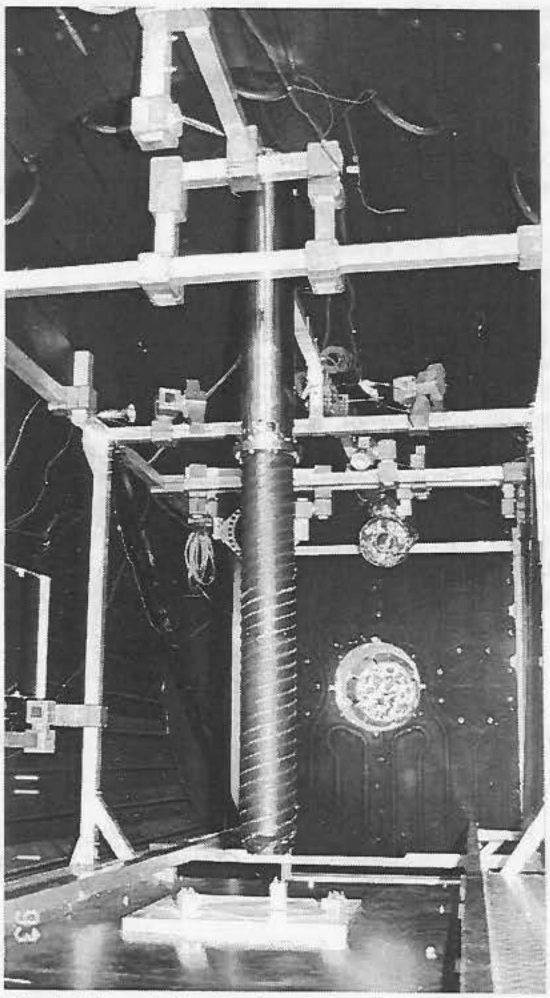
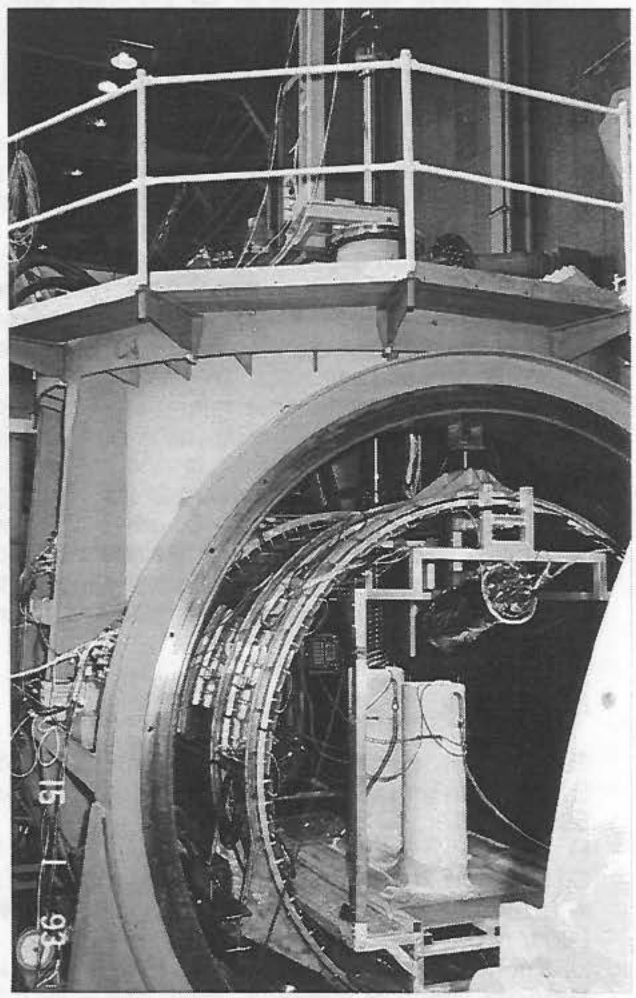
Having in view the realization of a "Comet Nucleus Sample Return Mission" or even at least a "Comet Nucleus Sampling Mission", the European Space Agency funds the technological development of the so far needed Sample Acquisition Tools. These tools are a corer 1m in length and 15 cm diameter with an internal shutter system, a surface tool for sampling tasks on a surface consisting out of dust- and ice-grains, and pebbles and an anchoring system for the spacecraft lander. The first thermal-vacuum test of the preliminary corer was performed in January ´93 in the DLR´s Space Simulator.
The coring machinery was built by an industrial consortium headed by Tecnospazio. DLR was responsible for the test performance and the delivery of two samples 1.10 m in height and 0.30 m in diameter consisting of pure ice and a "cometary analogous" ice-/mineral-mixture. Both samples were hardened by sintering in a cold lab. The latest test results of the prototype tools are presented in the poster.





The left hand figure shows the integrated corer, the right hand side figure the sample containers,the corer above the backward sample,and the coring actuator on top of the Space Simulator.

Reference:

ROSETTA, Comet Nucleus Sample Return, Mission and System Definition Document, ESA SP-1125, 1991, editors G. Schwehm and Y. Langevin.

Mantle Dynamics and Dust Emission Phenomena at Cometary Analogous Ice-/Mineral-Mixtures

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During the last six years the "Comet-Simulation Program (KOSI)" was funded by the Deutsche Forschungsgemeinschaft. This program will be closed in 1993 and so it seems worthwhile to review the results in the view of findings gained during the last experiments dating in the end of 1992. [Grün et al., 1987 and Kochan et al. 1988]

In more than 10 large scale experiments performed in the Space Simulator of DLR Köln a lot of physical processes within the model comets, at their surface and shortly above, for the first time have been investigated "in situ". DLR developed different video camera systems to monitor the ice sample´s surface from different aspects, the total view of the surface with zooming possibility as well, as views in azimuth and in elevation.

In general it came out, that the ice-loaded dust particles are not loosely deposited on the insolated surface. They glue together by sintering processes. [Kochan et al., 1990, 1991] Before these particles can entrain into the gas jet, their connecting bonds to the neighbors have to be eroded. Sintering takes place within the complete ice-/mineral-matrix [Ratke, et al., 1992]. Just below the surface the porous material is hardened in addition to the sintering process by recondensation of the sublimated water vapor.

In series of experiments with different ice-/mineral mixtures we found that dust mantles preferably are formed during insolation periods with low irradiation intensity. Intensifying the insolation, avalanches within the dust mantle occurred, directly correlated with bursts of emitted particles. The IR cameras also monitoring the sample surface, immediately show a decrease in temperature within the avalanche area. This indicates an exposure of fresh ice-/mineral surface. The avalanches seem to be an important mechanism of a local and a time variation of the "cometary" emission activity.

To get a better understanding of the gas-particle interaction, physically defined by the drag force of the gas-flow exerted on the particle, the particle emission was observed in a combined effort from different sites of diagnostics. To get a synoptic view of all processes, all monitoring systems used the same radio transmitted time reference. The particle dynamics was monitored by the different video cameras (velocity) as well as by piezoelectric impact detectors (momentum) and ice-collectors. Fluffy aggregates with sizes of 500µm and masses ranging from 0.2µg to around 23µg were recorded respectively collected. In addition to the investigation of these emitted particles, the entrainment of fluffy aggregates ranging from 400 µm to 1000 µm in size, injected from above into the gas jet is also observed. The reaction of these "well defined" particles with the jet is another clue to the gas particle interaction processes. The evaluation is rather promising to deliver drag coefficient and gas velocity data. The "synoptic" view of the mantle dynamics and the particle emission will be given in the presentation.

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Particle emission in the comet simulation project KOSI: A review of five different experiments

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In a series of comet simulation experiments mineral ice mixtures are studied under space conditions [Grün et al. 1991a]. The emission of ice, mineral-ice, and dust particles during the illumination phases is investigated by different devices: The particle emission was first established in form of a spatial distribution of the deposited dust particles in front of the sample after the experiment. From this distribution the total mass loss of the sample with respect to minerals can be estimated. The time dependence of the emission activity is recorded by piezoceramic impact detectors [Kohl et al. 1989], ice/mineral and dust collectors [Mauersberger et al. 1991 and Thiel et al. 1991a, 1991b] and a laser particle counter [Kohl et al. 1989]. The particle emission can be directly observed by video cameras [Kochan et al. 1991]. The time dependence of the particle emission rate is related to the thermal evolution of the sample [Benkhoff and Spohn 1991] which in turn depends on the sample composition and the duration and intensity of the illumination. The relevant near surface parameters for the particle emission are the flux density of the outflowing gas [Hesselbarth et al. 1991] and the surface temperature of the sample [Grün et al. 1991b]. These parameters also give information about the development of a dust mantle on the sample surface.

The present paper gives a review on the dust results of five comet simulation experiments. In all experiments the maximum gas flux was observed immediately after the start of illumination. This high flux is accompanied by the maximum emission rate of ice containing particles. The gas and dust emission activity in all experiments decreases more or less steeply with increasing irradiation time, whereas the surface temperature increases to an asymptotic value. Near surface parameters that are relevant for the particle emission activity are discussed for the five experiments investigated.

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Powerful Bolide Explosion Over the North Italy

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In the night of January, 19. 1993. at 00:33:20 ±15 sec. UT, many people from north Italy, Switzerland, Slovenia and Croatia witnessed a very bright flash in the sky. The fireball entered the atmosphere over the Adriatic sea from azimuth of 310° ±15°(SE-NW), inclination lover then 20° and the mass greater than 50 tons. The velocity was greater then 20 km/s. The luminosity in the first part of the flight was M≈-13 with incrementing intensity and on the end a very intense flash.

The complete destruction of the body was over the Italian region of Emilia, between the cities of Bologna, Faenza and Lugo, on the high of 20-25 km from the Earth surface. During the flash that lasted from one to two seconds the intensity of light varied having two distinct peaks. At the peaks of the luminosity, the globe emitted from 1 to $5 \times 10^{13} W$, and possibly some tenths of KT of energy was liberated as light.

Because the flash occurred near a cloud layer, it was intensively illuminated and distant observers described this effect as baffles or horizontal jets.

In the region of Emilia the low frequency roar (thunder) was also heard, some 80 seconds after the flash. The sound was very deep and strong. For twenty seconds the windows and, in the city of Faenza, walls, also vibrated.

Possible change in intensity of Earth magnetic field was also recorded in central Italy from 0:56 and 1:00 UT. By misfortune the direction of flight of the body was out of the region that it is monitored by the fireball European Network.

Near the city of Porec (Croatia) one house started to burn for the reasons other than the seen fireball, but some eyewitnesses connected the flash in the sky with the house fire, and from that begun a newspaper and TV story that wrongly divulged the story of a fall of a meteorite.

The observed event is very remarkable and the presented data are the best possible to have been collected till now. This is one more case that very massive meteoroids or small asteroids of group (type) I are completely destructed by aerodynamic pressure. This is also further confirmation that during Earth collision with small bodies that maintain high velocity depth in the atmosphere and have lover resistance to pressure, these bodies are destructed before they reach ground, leaving no geological consequences.

Now the search for possible downfall of condensed meteoritic material from the plasma globe sizing microns, in the region of epicentre is in progress. The possibility to have more detailed data exist if some of the satellites for early warning bearing infrared radiometer, registered the emitted infrared radiation of the fireball.

New method for the study of airborne meteoritic particles trapped on tree-resin: some results from the Tunguska region

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After powerful air explosion of large meteoroids and small asteroids that have not the structural strength to survive the aerodynamic pressure during penetration in the dense part of atmosphere, the only possibility to reconstruct the bodies compositions after the event are:

Either to search in the strewnfield for possible meteorites that entered the atmosphere separately from the main body, or to search micron sized particles condensed from the plasma globe. The till now used natural traps for search of deposited small particles were peat bogs, glaciers, lake, swamp and sea bottoms. The difficulty to work with samples collected in those places is the enormous number of ballast particles that complicate the search enormously, as well as the problem of the dating of the layers.

During the first International Tunguska Expedition (ITE) four km SE from the epicentre of the Tunguska explosion, in the test excavation in search of the 1908 ash layer the first peace of tree resin in the ground was found. The number of ballast particles was lower that in the peat, swamp or lake sediments but still very high. Fortunately by serendipity, on the cross section of a red Siberian tree trunk (*Picea obovata*) about 160 year old, cut 5 km NW of the epicentre of the explosion, one very interesting feature was found after polishing. The cross section revealed a horizontal branch emerging from the stem, debarked long before the explosion. Resin on the scar was renewed year by year. The tree resin was then completely embedded in the growing wood. In such clean trap the particles are preserved from the following airborne contamination in the next years. The dating of the trapped particles is possible by counting the tree rings, and only small shift in position was possible due to the pressure of the growing tissue. The tree slice was cut into pieces corresponding to the year 1908, and earlier and latter years, and resin samples were prepared for conventional scanning electron microscopy (SEM) and field emission SEM (FE-SEM)observations , and for X- ray microanalysis , in order to detect if and what kind of particles are trapped in the resin.

During the morphological investigation on the 1908 ring the number, type and size of particles embedded in the resin are found : 14 Ca carbonates and/or oxides 1-5 μm, 6 Fe chloride and sulphide 1-5 μm, 5 (Na, K, Ca) chlorides 10-15 μm, 5 Bi 1 μm, 4 Ba sulphide 1-5, 3 (Na, Al, K) silicates 2-3 μm, 2 Pb-Br 1 μm, 1 Co-W 1 μm, 1 Ca-Ti-Fe 1 μm, 1 Fe-Ni 1 μm. In the period from 1908.-1910. also a enstatite crystal sizing 30 μm was found, with submicrometer Ba sulphide particle, and submicrometer and micro-sized particles of Ca, Fe, Cu, Zn, Au. The presence of aggregated particles in the resin 1908.-1910. similar to those found in the cosmic dust collection confirmed to us the validity of the tree-resin traps. Except for Ca and chloride particles the composition reported above had been found only in the years 1908-1910., none in the confining rings. Calcium carbonates and/or oxides are common in plants and are not to be considered related to the Tunguska body composition.

The (SEM) (FE-SEM) and X-ray microanalysis of the tree resin traps are the formidable new way to study the unsolved collision of Earth with the small bodies of the Solar system in the last time as Tunguska 1908., Rio Curaca 1930., Marudi mountain 1935., Revelstoke 1965. and the last Emilia 1993. Also with these new method it will be possible to search for fallen cosmic particles before the contamination of the atmosphere in the last centuries. If we use mineralized tree resin (amber) for the analysis it is also possible to study the trapped cosmic dust particles during the geological ages.

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ANALYSIS OF P/BRORSEN-METCALF H_2O^+ BRIGHTNESS PROFILES BY MEANS OF THE MONTE CARLO SIMULATION

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The long-slit spectra of Comet P/Brorsen-Metcalf were obtained on the high-altitude station "Terscol" of the Main Astronomical Observatory of Ukraine using image intensifier "Topaz". To investigate the H_2O^+ ionosphere we extracted the brightness profiles of the 8-0 and 6-0 H_2O^+ bands.

On the base of the Monte Carlo formalism we developed the computing program to simulate the distribution of observed species in cometary atmospheres. Using this model we calculated the spatial distribution of the H_2O^+ ions in P/Brorsen-Metcalf atmosphere and fitted the computed H_2O^+ profiles to the observed ones. We obtained the H_2O^+ acceleration in the tailward direction to be 10–13 $cm \cdot s^{-2}$. According to our simulation the ionization H_2O lifetime is $2.2 \cdot 10^5$ s. The lifetime of H_2O^+ against its disappearance turned out to be $(1.9-2.0) \cdot 10^5$ s. Our simulations have showed that the comet-solar wind interaction is crucial in the formation of the H_2O^+ cometary ionosphere.

SPECTROSCOPIC OBSERVATIONS OF COMET P/BRORSEN-METCALF AT 3500-7550 WAVELENGTH REGION

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The spectroscopic observations of Comet P/Brorsen-Metcalf were made on the high-altitude station "Terskol" of the Main Astronomical Observatory of Ukraine on August, 1989. The spectra were taken using image intensifier "Topaz" with the UMK-91VM image-tube as the basic unit. The spectra cover the wavelength region from 3500 to 7550 A° at resolution ranging from 1.8 to 7.7 A°.

We carried out the identification of 329 spectral features in P/Brorsen-Metcalf spectra. We found emissions of CN, C_2, $^{12}C^{13}C$, CH, C_3, NH_2, Na, O[I] neutrals, and N_2^+, OH^+, CO^+, CH^+, CO_2^+, H_2O^+ ions in our spectra. We detected the transitions from the rotational levels up to $J''=99$ for the $\Delta v=0$ C_2 sequence for the first time. We found five features which coinside with the laboratory band heads wavelength for HCO, and three ones which coincide with the heads of the Swan "tail" bands as well.

Three-dimensional Model of Ray Structure Formation in Cometary Plasma Tails

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The physical model of large-scale ray structure formation been proposed in preceding paper [1] resides in the consequential development of ion-acoustic instability and filamentational one due to the solar wind flow penetrating into the cometary plasma. The latter instability consists in the solar wind flow division and that of cometary plasma into separate current layers.

In order to study a real form of the filaments and instability development in space a study of the proposed mechanism in three dimensions in terms of hydrodynamic equations for ions and electrons was made. Our main interest here was with the large spatial scales which are not affected by thermal effects [1]. Consequently, all the components were considered to be cold. Cometary plasma ions and those of the solar wind seemed to be collisionless, otherwise collisions of electrons dealing with scattering on ion-acoustic oscillations were characterized by effective collision frequency [1]. The cometary plasma filaments, which are observed as bright rays, were formed due to instability development. They took the form of cylindrical plasma fibers with thickness determined by cometary plasma parameters and those of the solar wind. Plasma density in the filaments varies as $J_0(kr)$, where J_0 is the zero-power Bessel function, k is the parameter playing the role of transverse wave number. Under some assumptions we obtained characteristic length which may be thought of as the maximum ray size:

$$l_{max} \simeq 4.8/k_0 \simeq 4.8 \cdot \frac{V_{0i1}\omega_{pi1}}{\omega_{pi2}\omega_{Hi1}} \simeq 10^3 \div 10^4 \text{km}.$$

Here V_{0i1} is the solar wind flow velocity, ω_{pi1} and ω_{pi2} are plasma frequencies of the solar wind and cometary plasma, ω_{Hi1} is the electron cyclotron frequency. The obtained spatial scales are in a good agreement both with one-dimensional theory [1] and the observational data. We can evaluate the number of rays within one lobe of cometary plasma tail, which is approximately equal to $L \cdot k_0/11.2$, where L is the system length, and varies at range of 2÷30 rays.

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COMETS (existing populations)

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The huge system of comets, filling the whole interplanetary space and surrounding it to more than 1000-times the distance of Pluto, is unique not only by its size but, in particular, by entirely different evolutionary scales of its individual subsystems. The members of the Oort cloud are apparently the most primitive objects of the solar system. Only rare star passages reduce the heliocentric velocities of a small fraction of these comets from about 100 m/s to less than 2 m/s, which is a prerequisite of the injection into the vicinity of the Sun, starting their activity and making them detectable as "new" comets. This transfer takes typically 2 to 3×10^6 years. After the first passage near the Sun, almost one half of these objects escape from the solar system, and the revolution periods of the others drop mostly to less than 10% of the original value, changing them into "old" comets.

Another persistent source is the Kuiper belt, located at the boundary of the planetary system, about which we have only indirect evidence. It is the necessity of progressive replenishment of the system of short-lived short-period comets, and incompatibility of its strong flattening with the structure of the Oort cloud. There are different views on the long-term stability of the outer Oort cloud, in connection with the encounters with giant molecular clouds; and comets from the Kuiper belt can also provide its replenishment and maintenance.

Only recently the first probable member of the Kuiper belt - 1992 QB1 - was discovered. Its size, as well as that of 2060 Chiron and P/Schwassmann-Wachmann 1, lend support to the opinion that progressive disintegration of larger objects may play here even a more important role than individual dynamical captures. As a result, the cometary population of the inner solar system can undergo considerable non-random variations with time. Through the comets of Halley type, forming the inner boundary of the system of long-period comets, we come to the highly flattened Jupiter family. Our knowledge of this subsystem is much more complete than that of any other. It is of basic importance for our understanding of the whole comet population because it evolves on very short time scales covered by astronomical observations, the survival time of its active members being only about 10^{-6} of the age of the solar system.

The variable population and structure of the Jupiter family of comets is governed by the frequency and efficiency of planetary encounters, the course and impact of orbital resonances, nongravitational accelerations, splits, outbursts, and transient dormant phases. The process of physical ageing makes the dynamical evolution asymmetric; the injections into the inner planetary system are only to about 10% compensated by the ejections, and for a majority of objects the final fate is a total extinction or disintegration. This implies direct relationships to other systems of interplanetary objects: formation of dust trails, their dispersion into meteor streams, contribution to the maintenance of the zodiacal cloud, and mixing of the population of extinct comets and their fragments with similar objects of asteroidal origin.

Updating of the catalogue of absolute magnitudes of periodic comets

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Our catalogue of absolute total magnitudes of periodic comets has been updated by including the apparitions of comets which passed their perihelia in 1988-1992. The total number of objects has increased from 144 to 172, that of the objects of more than one apparition from 89 to 106, and the sum of apparitions from 575 to 661. In addition, seven entries from 1959-1987 were changed by observations published after 1987.
Comparison of the new data with the older ones does not reveal any signatures of progressive fading. On the contrary, 60% of the objects were brighter than at the previous apparition and 67% brighter than the long-term average. The corresponding weighted means of ΔH are -0.2 and -0.5 magn., respectively. This brightening is spurious and can be attributed to the failure of rediscoveries of a few objects which became fainter, to a better time coverage by photometric observations, and to the reduction of instrumental corrections for faint comets by the application of modern techniques, like CCD Spacewatch.
Quite exceptional is P/Metcalf-Brewington, which remained unobserved for 10 returns and this time was 3.4 magn. brighter than at the discovery apparition in 1906. Three other long-lost comets - P/Peters-Hartley, P/Swift-Gehrels and P/Tempel 1 - were also substantially brighter than ever before, indicating a renewal of activity, and the increased brightness persisted for P/Tempel 2 and P/Honda-Mrkos-Pajdušáková. Unusual activity (more than 2 magn. above the average) was recorded far from the perihelion for P/Gunn, P/Giacobini-Zinner, P/Churyumov-Gerasimenko and P/Sanguin. However, with the exception of P/Gunn, the instrumental effects tied with a very low apparent brightness do not allow to draw any definite conclusion about their possible outbursts. The comets discovered during their immediately preceding perihelion passage tend to become fainter; for P/Machholz, P/Takamizawa and P/Hartley 2 this suggests a decline following after a sudden renewal of their activity.
Our main data sources were IAU Circulars, Minor Planet Circulars and International Comet Quarterly. If there are any unpublished photometric measurements/estimates from around the brightness peaks we would greatly appreciate receiving them.

THE ORBIT OF (4179) TOUTATIS FROM OPTICAL AND RADAR DATA

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The technique used in the present investigation for processing both optical and radar observations was described earlier [1]. The technique was there applied to the data for asteroid (1862) Apollo and a comparison with the results of other researchers [2] was made. In this paper the technique was used for orbit determination of (4179) Toutatis on the base of all available data (optical observations from 1934 to October 1992 and radar data, delay and doppler, obtained in 1992 during asteroid's approach the Earth). The total number of optical observations is equal to 320 and that of radar 28 (the latter were kindly sent us by D.K. Yeomans).

The addition of 28 radar observations to optical ones reduced the errors of orbital elements as follows: more then 20 times for the major semiaxis, 3 times for $e\sin\pi$ and $e\cos\pi$, and 3 times for the mean longitude. The normalized RMS for different kind observations are: optical - 1.35, delay - 1.74, Doppler - 1.76, total - 1.35. An attempt to determine corrections to the asteroid radius and to the zero-point of the reference catalogue was made.

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Plasma tail of comet Bradfield 1987 XXIX

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A set of thirteen large-scale exposures of comet Bradfield 1987 XXIX taken between 1987 November 8 and December 25 is evaluated. The observations were obtained with the 63/85/187 cm Maksutov telescope of the Klet' Observatory. The studied plasma tail with visible plasma rays, kinks, and disconnection events extends out of the field of the plates. Therefore, the tail must have been longer than 1.7°. The dust antitail on the best exposures is long up to 0.5°

For this period the solar wind velocity is determined from the aberration angle of the plasma tail in the comet's environment. The determined value of the solar wind velocity are compared with satellite data recorded near the Earth. For the visible plasma kinks a radial and a tangential velocity is determined.

The collisional history of the eucrites asteroid

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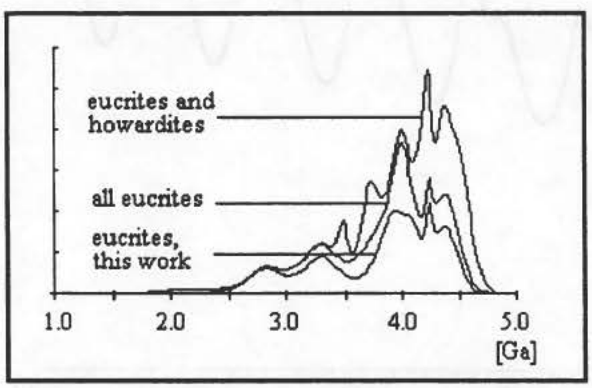
Since it was demonstrated that eucrites (achondrites, which are very similar to terrestrial basalt) do not derive from the moon, the question remains, which asteroid has suffered an extensive basaltic volcanism during an early stage of the solar system and thus would be the parent body of eucrites and the petrologically related howardites and diogenites. Spectrophotometric analysis [1] suggests a link with Vesta 4 though there are some dynamical problems to explain the material flux from Vesta to Earth. Recent results demonstrate the existence of some small asteroids that are most probably *chips off of Vesta* [2] and may be the intermediate source for the eucrites. While Sm-Nd ages of ≈4.5 Ga [3] most probably date the crystallisation of the parent body's crust it is expected that by ^{40}Ar-^{39}Ar analysis the duration of secondary processes like brecciation, reheating, and recrystallisation caused by collisional events can be obtained as the K-Ar system can rather easily be disturbed or reset.

Here we report on a high resolution ^{40}Ar-^{39}Ar study of matrix samples and individual clasts from five Eucrites: Stannern, Pasamonte, ALH 76005, ALH 78132 and ALH 80102. Most age spectra are complex: In general the apparent ages increase with increasing degassing temperature and in some cases are additionally disturbed by ^{39}Ar recoil. So the low temperature ages provide estimates of the time of the last thermal disturbing events while the high temperature ages give lower limits for the last total degassing of the rocks. Another general feature are the K/Ca spectra which for all samples are almost constant for the first 70 % of ^{39}Ar release and then level of by about one order of magnitude.

Our results are in good agreement with those of other workers [4–7] and support a period of cataclysmic bombardment on the HED parent body combined with total resetting of the K-Ar system 4.4–3.9 billion years ago which was followed by a period of less intense impact induced metamorphism causing partial loss of radiogenic ^{40}Ar 3.9–2.8 billion years ago.



Histogram of ^{40}Ar-^{39}Ar ages from this work together with the results of other authors [4–7]

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PERTURBATIONS OF (1) CERES ON (3643) 1978 UN_2

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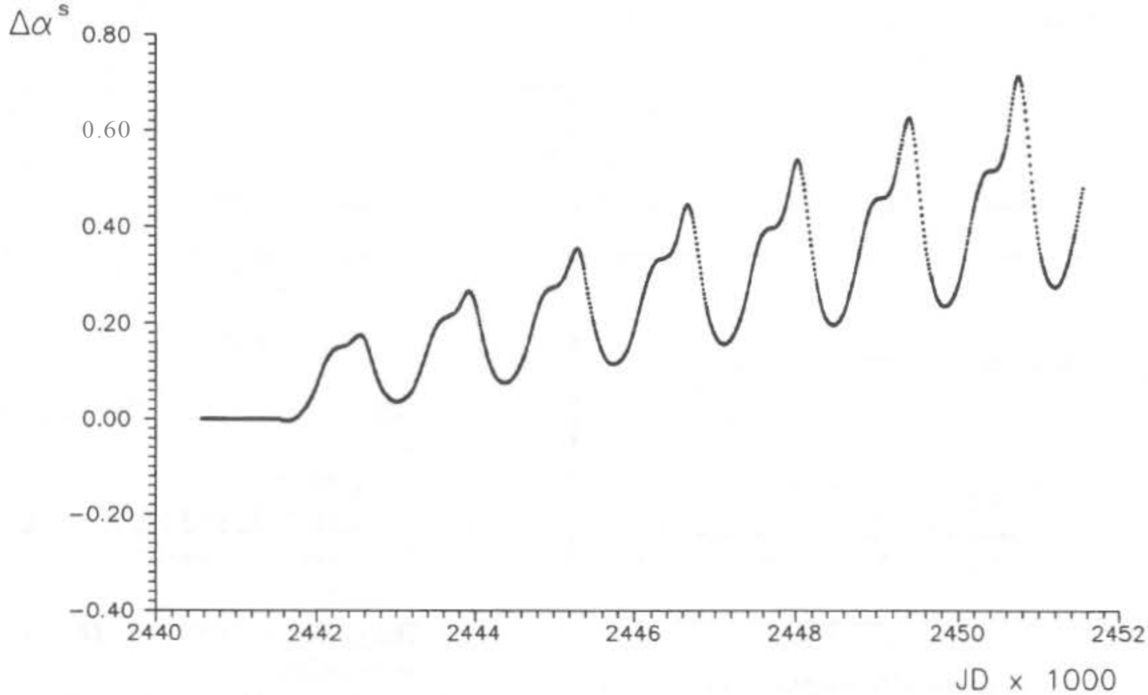
While systematically searching for the close encounters between asteroids in a recent past, we found many cases of close encounters with the largest bodies. In several such cases a significant change of motion of perturbed body occured after the approach. Here we would like to present the case of encounter between (1) Ceres and (3643) 1978 UN_2, in which the changes of this latter asteroid's heliocentric equatorial coordinates, due to the encounter, were quite large. The asteroids reached the minimum mutual distance of $0.0083\,AU$ on September 6, 1971, with a relative velocity of $2.76\,km/sec$. In order to analyze this case in more detail, we performed a numerical integration of perturbed asteroid, once under the perturbation of all the major planets except Pluto, and the other time adding in the perturbing effect of Ceres (assuming its mass to be $5.9 \times 10^{-10} M_\odot$), in a time span starting 1000 days before the epoch of a close approach and ending up at the year 2000.0. The obtained differences of right ascensions are presented in Figure below. Providing the precise positions of (3643) are derived from the past and the future observations (the next opposition is on December 1, 1993), the mass of (1) Ceres can be redetermined and hopefully improved.



ANALYSIS OF THE TIME-SHIFT EFFECT IN ASTEROID LIGHTCURVES

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A time-shift, used in Photometric Astrometry, is an interval of time between the moment, at which the maximal cross-sectional area of the asteroid faces the Earth, and the moment, at which the observer measures the maximal brightness of the asteroid light variations.

Up till now two methods has been proposed to calculate time-shifts. According to Taylor (1979), time-shifts can be obtained as half the difference in asterocentric longitudes of the Earth and the Sun. Another approach, proposed by Harris (1984) and Magnusson (1983), consists in calculating time-shifts as a difference in asterocentric longitudes of the Earth and the Phase Angle Bisector. In most cases both methods give the same values for time-shifts. There are geometries, however, at which significant differences appear.

To analyse this problem, a set of numerically modelled lightcurves was obtained for different aspect, obliquity and phase angles. The models used in calculations had shapes of triaxial ellipsoids with different axis ratios. For each lightcurve, a time-shift was obtained, according to the general definition given above. It was compared to the time-shifts, calculated with analytical formulae. This procedure was repeated with different laws of light scattering (Lommel-Seeliger's, Bowell-Lumme's and Hapke's). The results showed that the time-shifts obtained from numerically calculated lightcurves are generally independent on the axis ratios of the models and on the scattering laws. Differences between numerical and analytical time-shifts appeared when the rotation axis was in the region between the sub-Earth and sub-Sun points.

The next step was to check what errors can be made by using the analytical time-shifts in case of more realistic models of asteroids. The most significant results were obtained with the model of 433 Eros - some of them are presented in the table below.

Y	M	D	Asp	Obl	PA	Max	Min	PAB	CPA
51	9	25.0	162	97	19	99.0	100.8	172.1	121.6
51	10	4.0	159	108	19	115.2	122.4	166.5	149.5
51	10	11.0	156	113	20	124.2	133.2	165.0	152.3
51	10	15.0	155	115	22	127.8	135.0	163.1	150.1
51	12	13.0	160	130	49	120.6	118.8	93.5	118.5
52	2	11.0	158	283	59	7.2	9.0	8.1	5.6
72	8	4.0	140	332	17	7.2	9.0	10.8	10.0
74	8	22.0	150	92	42	91.8	93.6	175.5	93.3
74	10	18.0	118	120	42	156.6	163.8	165.0	159.1
75	5	3.0	46	257	44	131.4	140.4	168.3	142.5
81	12	18.0	150	213	41	162.0	156.6	155.3	160.8

Explanations :

Y,M,D - year, month and day of one of observations of Eros, taken from the Asteroid Photometric Catalogue (Lagerkvist et al., 1987)

Asp , Obl, PA - aspect, obliquity and phase angle (in degrees); obliquity is defined here as a dihedral angle between the plane of the aspect angle and the plane, perpendicular to the phase angle; obliquity is measured counter-clockwise

Max, Min - time-shifts (in degrees) obtained from numerically modelled lightcurves; Max denotes the time-shift of the maximal brightness, Min - of the minimal; the accuracy of Max and Min is +/- 1 deg.

PAB,CPA - time-shifts (in degrees) obtained from analytical formulae, based on definitions of Harris (1984), and Taylor (1979), respectively

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DETERMINATION OF PHYSICAL PARAMETERS OF NEAR EARTH ASTEROIDS

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There are several methods for obtaining, from the observed light variations, physical parameters of asteroids (such as sidereal periods, spin orientations, triaxial ellipsoid approximation of shapes, H,G parameters of phase curves). Most of them are successfully used for Main Belt objects. Earth Approachers, however, are observed at quite different geometries (the crucial for the following disscussion are large phase angles and quick changes of aspect and obliquity during a single apparition). This makes classical methods difficult to use - in practice, only Photometric Astrometry can be applied to NEAs without bigger changes. The other comlimentary approaches (amplitude-aspect and magnitude-aspect methods) reveal many problems when used for NEAs. In fact, during the last decade, only Drummond (1990) used full EAM method to obtain physical parameters of two Earth Approachers: 1580 Betulia and 3908.

In the present work, new elements are introduced into the classical EAM method to avoid the above mentioned problems. Amplitudes and magnitudes are calculated by integration of one of the light scattering laws over the visible, illuminated surface of a triaxial ellipsoid. As this is a time-consuming process, only two points of the ligthcurve (of maximal and minimal brightens) are calculated. Rotation angles, which define these points, are obtained from time-shifts. Time-shifts are also used for calculating epochs of lightcurve extrema. This part of the algorithm does not differ from the classical Photometric Astrometry, with one exception: there are geometries, at which numerical time-shifts are used instead of the ones, obtained from the analytical formula (see "Analysis of time-shift effect in asteroid ligthcurves" in this volume for details).

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A search for asteroids and comets in the direction of Jupiter

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The ESO Schmidt telescope was used during March and April 1992 and 1993 to search for asteroids and comets in a 16 by 16 degrees field centered on Jupiter. On the 1992 plates no comet brighter than the corresponding point source V magnitude 21.4 was found, thus giving an upper limit on the number of comets in the Jupiter family (Tancredi and Lindgren, *Icarus*, subm.).

On the March 1992 plates a total of 4136 asteroid trails were identified, coming from some 1300 asteroids. On the plates from the follow-up observations in April 1992 more than 600 trails were found to be linked to the trails on the March plates. A comparable number of new asteroids can be expected from the 1993 observations.

We will present final results on the upper limit on the Jupiter family as well as statistics on the orbits of the asteroids and a comparison with results of the Palomar-Leiden survey.

Differential CCD Photometry of 1980 Tezcatlipoca, 2368 Beltrovata, 4769 Castalia, 4953 1990 MU and 4954 Eric

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Mats Lindgren
Claes-Ingvar Lagerkvist
Gerhard Hahn

Abstract

Lightcurves of five near-Earth asteroids were obtained by CCD photometry in May 1992, with the Dutch 0.91 m telescope at ESO, La Silla, Chile. The weather conditions allowed only differential photometry and a method was developed to compare the different reference stars when an asteroid was moving too quick for a single star to be used as a reference for a whole night.

A rotational period of $4^{\mathrm{h}}.08$ is determined for 4769 Castalia with a lightcurve amplitude of approximately $0^{\mathrm{m}}.5$. The rotation periods are estimated for 1980 Tezcatlipoca ($\sim 6^{\mathrm{h}}$) 2368 Beltrovata ($\sim 5^{\mathrm{h}}$) and 4954 Eric ($\sim 12^{\mathrm{h}}$), all of them with a lightcurve amplitude of about $0^{\mathrm{m}}.9$. The 2.5 hours of observations of 4953 1990 MU did not give enough information to indicate any period, although the amplitude is at least $0^{\mathrm{m}}.3$.

Inversion of Asteroid Photometry

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Abstract

Much of the theoretical basis for inversion of photometry to derive asteroid shapes and/or albedo variegation maps was developed by Kaasalainen *et al.* , *Astron. Astrophys.* **259**, 318-332 (1992). We have initiated a project aiming (1) to adjust the method for optimum usage of available asteroid photometry, including relative photometry and small lightcurve "pieces"; (2) to apply it to a survey of as many asteroids as possible; and (3) to attempt to draw cosmogonically interesting conclusions from the results, such as statistics on hemispherical albedo variegation, departure from ellipsoidal shape, and a better separation of original objects from collision fragments. We will present our basic assumptions, inversion technique, test cases, and (hopefully) preliminary results for some real asteroids.

ABSOLUTE PHOTOMETRY OF THE DUST TAIL OF COMET P/HALLEY. P. Lamy and P. Malburet, Laboratoire d'Astronomie Spatiale, CNRS, BP 8, 13376 Marseille Cedex 12, France.

Postperihelion observations of the tail of comet Halley were performed with a wide-field CCD camera set up at the European southern observatory. One hundred images were collected over a period of several months, through B, V, R, and, occasionally, I filters. We implemented a quasiautomatic procedure for the reduction of the images, using a large number of stars for absolute calibrations. The procedure, as well as the results for the B and V filters processed so far, will be presented.

OBSERVATION OF COMET FAYE (1991n) WITH THE HUBBLE SPACE TELESCOPE. P. Lamy and I. Toth, Laboratoire d'Astronomie Spatiale, CNRS, BP 8, 13376 Marseille Cedex 12, France.

Periodic comet Faye was observed with the Hubble Space Telescope when it came to within 0.6 AU of the Earth in October–September 1991. At this distance, the projected pixel of the planetary camera corresponds to 20 km. The observations through a broadband red filter were performed seven times to follow the possible activity of the comet. The outer coma is highly asymmetrical clearly deviating from a simple 1/r model. The analysis of the innermost coma is complicated by the spherical aberration of the HST. Various deconvolution schemes were tested and indicate also a nonisotropic emission of dust. The contribution from the nucleus was delineated and may give access to a direct characterization.

CHANGING PROPERTIES OF THE DUST COMA OF P/HALLEY: IMPLICATIONS FOR AN INHOMOGENEOUS NUCLEUS. P. Lamy, C. Cosmovici, and G. Schwarz, Laboratoire d'Astronmomie Spatiale, CNRS, BP 8, 13376 Marseille Cedex 12, France.

High-resolution maps of the color and polarization of the coma of comet Halley derived from CCD images obtained during the first half of March 1986 reveal considerable temporal as well as spatial variations. They remain however restricted to the inner coma and are well correlated with the activity of the comet. The varying reddening and polarization are best explained by a population of organic grains that do not survive beyond a few tens of thousands of kilometers. Color and polarization do not exhibit a unique correspondance. Taking into account the rotation of the nucleus, this implies an inhomogeneous nucleus. The maps of the color, the polarization and the jet structures as revealed by unsharp masking are correlated to delineate the physical properties of the dust grains in the jets and in the background coma.

ACTIVITY LEVELS OF COMETS AT LARGE HELIOCENTRIC DISTANCES:

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The activity level of 60 comets observed in red-band CCD imagery since 1985 have been measured in terms of coma size, tail length and total brightness when at $r > 1.5$ AU. About 30 of these could be followed over substantial segments of their orbit, or multiple orbits. For this range of r, it is assumed that only dust is being measured, but the intrinsic dust/gas ratios of many of the comets are not known. The substantial homogenous data sample is sufficient to consider studying the range of activity (and appearance) among comets of varying evolutionary histories (aging) and possibly different formation environments. Consistent with other studies, we find that new comets are more active at large r inbound, and that several comets display substantial tail development even at $r>8$ AU. At this preliminary stage of analysis, there is no clear correlation between the measured and the orbital characteristics. The brightness behavior of many of the periodic comets exhibit the common postperihelion dust production increase.

Dust and gas brightness profiles in the Grigg-Skjellerup coma from OPE/Giotto

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The OPE experiment on board the Giotto spacecraft has provided the first in-situ optical probing of the very inner coma of a short period comet. Along the trajectory, brightness profiles (both of solar light scattered by cometary dust grains and of light emitted by cometary gases) have been obtained in various channels, with a resolution up to 20 km, for distances to the nucleus below 10000 km.

These profiles allow us to estimate the size of the outer coma (dark and sunny sides) and to point out some local increases in brightness in the inner coma. Besides, on the dark side of the coma, the dust brightness profiles are found to nearly obey a r^{-1} law (where r is the nucleus distance), to be expected from a r^{-2} dust spatial distribution. On the sunny side of the coma, the power law is of the order of $r^{-1.7\pm0.1}$ and the profiles exhibit a negative curvature (Levasseur-Regourd et al., Planet. Space Sci., 1993). The gas emission profiles are also estimated of both sides of the coma. The relative contribution of dust and gas are discussed for the increases of brightness detected in the inner coma.

LARGE PROPER ELEMENTS FOR HIGHLY INCLINED ORBITS: TESTS AND ACCURACY. Anne Lemaitre, Facultés Universitaires Notre-Dame de la Paix, Département de Mathématique, Rempart de la Vierge, 8 B 5000 Namur, Belgium.

The classical method used to identify families of asteroids is the calculation of proper elements of all known asteroids followed by an analysis of the shortest distances between them. These proper elements are not easy to estimate; they have to be quasi-invariants of motion for very long periods of time and they are obtained by double average over the short and long periodic terms of the N body problem.

A very complete theory, based on series expansions in eccentricity and inclination, has been developed by Milani and Knevzevic in the years 1988–1990; a set of proper elements for numbered asteroids (1 to 1800), calculated by Williams in 1979, numerically, is available too. We have developed a third theory, mainly Williams's but expressed in action angle variables, to try to identify new families of asteroids, eventually nonnumbered and with high inclinations. Consistency, accuracy, comparisons, and results will be presented and discussed.

Polarimetric and photometric properties of cometary dust

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Numerous observations of brightness and polarization of solar light scattered by cometary dust grains had been performed during the return of comet Halley. The Giotto flyby of comet Grigg-Skjellerup in 1992 has allowed the first inner coma probing of a comet, down to a nucleus distance of about 200 km (Levasseur-Regourd et al., Planet. Space Sci., 1993). Besides, recent progresses in ground based imaging have allowed polarization images of cometary comae to be obtained (Renard et al., Ann. Geophys., 1992).

A large data set has therefore been obtained for various comets, in a large range of phase angles (1° to 110°), and with a significant spatial and temporal resolution. It is of interest to notice that the phase angle dependence of the linear polarization degree in the outer coma (nucleus distance greater than 2000 km) does not significantly depend upon the comet, at least as long as the solar distance is below about 2 AU and the phase angle is smaller than 45°. The wavelength dependence will be discussed, and the spatial variations that occur in the inner coma and more precisely in the near nucleus region and along dust jets will be analyzed.

These properties will be tentatively interpreted, while straightforward interpretations with spherical grains which poorly represent the irregular cometary grains will be avoided. Also, the optical properties of the cometary grains will be compared to those of i) asteroidal surfaces obtained from numerous asteroids observations, ii) interplanetary dust grains derived from inversion of zodiacal light and zodiacal emission data. Various questions about the composition, surface properties, porosity and evolution (e.g. fragmentation, sublimation) of these small bodies will be addressed.

The Origin of Jupiter-Family Comets

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We investigate the hypothesis that a trans-Neptunian belt of comets, the *Kuiper Belt*, is the source of the known Jupiter-family comets (periods $\leq$ 20 years). We present the results of numerical orbit integrations that track the dynamical evolution of objects initially in nearly circular orbits in the Kuiper Belt to visible Jupiter-family comets. Unlike all previous work in this area, the orbits of the comets are followed by *direct integrations* that include the effects of mutually interacting Jovian planets with the correct planetary masses. We employ a technique that effectively regularizes close encounters between comets and planets. This study is divided into two parts: the dynamical evolution of objects in the Kuiper Belt from nearly circular orbits until they become Neptune-crossers; and the subsequent evolution to visible comets.

We first present the results of billion year numerical integrations of the orbital evolution of more than one thousand test particles on initially low-inclination, low-eccentricity orbits within the Kuiper Belt. Particles which eventually crossed Neptune's orbit typically showed long periods (up to several billion years) of relatively low-eccentricity oscillations punctuated by a very rapid jump to Neptune-crossing eccentricity. We discuss the subsequent evolution of these particles below. An intricate structure in the region between 35 and 45 AU is found at the end of the billion year simulation.

We next follow the dynamical evolution of Neptune-crossing objects until they either become visible comets or are ejected from the solar system. We use the results of our first integration as a model for the initial conditions of this calculation. We compare the resulting orbital element distributions to those of the real Jupiter-family and find good agreement. We use these calculations to estimate the current number of objects in the active regions of the Kuiper Belt. We also estimate the number of invisible objects currently in the armada of comets moving through the outer solar system.

DETERMINATION OF THE SPIN ORIENTATION OF ASTEROIDS USING THE FREE ALBEDO MAP METHOD

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Abstract

Results for the pole orientation of the asteroids 31 EUPHROSYNE, 196 PHILOMENA, 338 BUDROSA AND 471 PAPAGENA using the Free Albedo Map Method (*FAM*) (Hainaut et al., 1990) are presented and compared with previous poles obtained by our group using two different amplitude aspect methods.

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The Orbit of the Eta Aquarid Meteor Stream

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A precise photographic orbit for the Eta Aquarid meteor stream has been difficult to determine, since the radiant (in Northern latitudes) is low in the sky and the shower is only visible for a short period of time before sunrise. Until recently the orbit quoted in the literature was based on one meteor only. In (Lindblad 1990) the mean orbit and radiant motion of the Eta Aquarid meteor stream was computed based on eleven two-station photographic meteors. An orbit based on five radio orbits observed by the Harvard Radio metor project was also presented. In the present study an improved orbit based on 21 photographic Eta Aquarid orbits is computed. The revised mean orbit agrees closely with that of comet Halley.

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The Statistical Significance of Small Asteroid Families

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Following the study of Hirayama (1918) a number of researchers have published lists of asteroid dynamical families in three-dimensional proper a, e, i-space. In these studies the major Hirayama families are identified and, for similar sized samples, have approximately the same members. Numerous small families with only a few members appear in most lists. In fact more than 60 different minor asteroid families have been proposed in the literature. An inspection of the data shows that the agreement between the classifications of various authors is poor. Several of the proposed minor families are various Flora sub-groups. These apparently arise when the investigator has decided to use a stricter rejection level for the Flora family than for the other families in his study. The present paper briefly discusses these results.

The paper next studies the probability that an asteroid family consisting of **n** members may have arisen by pure chance in a sample of **N** asteroids ($n << N$). This is done by constructing a large number of random asteroid populations each with N members. These populations are then searched for families using the D-criterion at the same rejection level as was used in the original family search (Lindblad 1992). Numerical values are given for this probability in a sample consiting of $N = 4100$ proper elements.

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The Orbit of the Perseid Meteor Stream as determined from Photographic Data

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In view of the increased interest in the Perseids we have computed a precise orbit for the Perseid meteor stream based on two-station photographic recordings. In the study all precisely reduced photographic orbits available at the IAU meteor data center in Lund (Lindblad 1991) were searched for Perseids. The Perseid orbits found in the search were checked for internal consistency of the orbital elements. These checks revealed some minor inconsistencies and it was necessary to reject a few orbits. The derived mean Perseid orbit is compared with that of previos determinations and with the orbit of the parent comet (Swift-Tuttle).

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The definition dependency of the duration of Jupiter family visits

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The population of what is generally called the Jupiter family is dynamically chaotic, and characterized by objects jumping in and out of the family (i.e. visits) on timescales of 10^3–10^4 years. This together with the fact that the observed population most probably does not represent the orbital distribution of the whole population of these objects, makes it necessary to make theoretical models of the dynamical transfer from different source populations.

As part of a larger project where the dynamical timescales of short–period comets are studied, some aspects of the problems concerning the definition of a visit of a comet to the Jupiter family will be discussed.

The presented results are based on a large set of numerically integrated orbital evolutions of fictitious comets with initial orbits in the Jupiter–Saturn region.

Contribution of Encke-type Cometary Dust to the Zodiacal Cloud

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Liou and Dermott (B.A.A.S., 1992) showed that cometary particles play an important role in the structure of the zodiacal cloud. We now estimate the contribution of Encke-type particles to the Zodiacal cloud. In our model we continuously release Encke-type dust particles from all points in an Encke-type orbit over the past five thousand years, then numerically integrate their evolutions including all planetary perturbations, Poynting-Robertson light drag, and corpuscular solar wind effect. We found that : (1). Trapping in mean motion resonance with Jupiter does occur, however the overall effect is not significant. (2). Jupiter produces a similar effect on the arguments of perihelion of the dust particles as it does to the short period comets. (3) While there is a huge dispersion in the orbital semimajor axes, particles with a given semimajor axis still define very well the forced elements. We apply those elements to a three-dimensional model SIMUL (Dermott et al., 1993) to calculate their overall flux contribution to the zodiacal background and compare the results with the observation from the Infrared Astronomical Satellite (IRAS).

On the Stability of the Cometary Ionopause

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Abstract

This paper discusses the stability of the sunlit cometary ionopause. Utilizing the ionosphere model of Comet Halley, which was discovered by Giotto Mission, we release our discussion to compressible condition. Meanwhile the distribution of plasma density is taken to vary as r^{-1} throughout the entire region, and then the magnetism magnitude vary as $B_m\sqrt{2r_m/r - r_m^2/r^2}$

SEARCH FOR MICROREMNANTS OF THE TUNGUSKA COSMIC BODY

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On 30 June 1908, at $07^h\ 14^m\ 28^s$, Local Time, the explosion of a cosmic body over a point (60° 53' 09" N, 101° 53' 40" E) in the basin of the Podkamennaja Tunguska River resulted in 2200 km^2 of forest fall and in a great number of trees and branches burnt in a large part of the explosion area. The nature and composition of the Tunguska Cosmic body (TCB) is still controversial. The two more plausible explanations consider the explosion in the atmosphere at an altitude of 5-10 km of a comet or an asteroid. In the last years the cometary hypothesis was favoured on the basis that a low density object was needed to explain the Tunguska catastrophe. Recently, it has been shown([1]) that, taking into account the effect of aerodynamic forces that can fracture the object, the TCB can be a normal density object and that the Tunguska event is fully compatible with the catastrophic disruption of a roughly 30 m diameter meteorite of the common stony class. However the same calculations don't exclude the possibility that the TCB was a high velocity iron object, nor rule out a carbonaceous asteroid as an explanation of the event. Taking into account that the input parameters of calculations are poorly known, the cometary impactor hypothesis cannot be considered definitely dismantled. The only way to reach the certainty about the nature and composition of the TCB remains the search for some of its remnants. Up to now, no impact craters or meteorite fragments have been found in an area of 15000 km^2. A bed-by-bed chemical analysis of the peat, in three different places of the Tunguska site, has given uncertain results. A great part of the spherules from soil samples, collected several tens of kilometres from the epicentre, have a terrestrial or micrometeoritic origin, though some of them are possible relic candidates for the TCB.

In the present work a new method is used to obtain experimental data on the nature of the TCB. The leading hypothesis is that in the forest conifers, as *Picea obovata*, which have survived the Tunguska catastrophe, the fluid resin freshly emitted for some physiological effect, could have acted as a trap, as it happens in amber, for aerial particles present at the moment of the event. In that type of tree, some resin is actually produced inside sapwood and partially emitted year by year to the exterior, in a fluid state, during the most active vegetation period. Part of it, deposited around little dead branches on the outer bark of the tree, solidifies and becomes gradually included from outside, by the growing wood. So if the fresh resin can act like a trap for aerial microparticles the part of them embedded in the tree can eventually be found in the resin layer along the limit between the growth rings and the withered branch. The growth rings, being rather easily datable, can give information on the age of the resin.

To collect the necessary wood samples from trees that have survived the catastrophe, the authors of the present work participated, in the summer of 1991, to an international expedition leaded by the academician N. V. Vasiljev and the astronomer G. V. Andreev from Tomsk([2]). The samples collected have the form of thin transversal stem slices, sawn at different heights, or of cylindrical cores extracted from living trees and containing the embedded withered branches covered by resin. After cutting the samples, in order to put in evidence the branches, the interstice branch-stems, containing the resin layers, were opened. Thus it has been possible to observe at a scanning electron microscope: a) the surface of the resin that was adjacent to the dead branches, b) the particles extracted after dissolving the resin inside filters placed in capsules of a soxelet. A Philips SEM 515, equipped with an EDAX PV9100 windowed X-ray spectrometer, has been employed to investigate the morphology, dimensions and chemical composition of the particles contained in the samples. The samples were mounted on SEM specimen stubs and subsequently coated with a 30 nm thick carbon film to prevent the accumulation of the electrostatic charge deposited by the electron beam. The SEM was operating at 30 kV with a specimen probe current of 5 nA. A computerised electron detector has been used for determining the concentration of components with atomic numbers greater than 10. The resin corresponding to the tree rings of the years 1890-1930 has been searched on 12 branches of 7 trees situated in different directions within a radius of 8 km from the epicentre of the Tunguska catastrophe. For comparison 6 other branches of a tree growing at more than 1100 km from the epicentre and the resin deposited on the roots of a tree uprooted by the explosion of 1908 have also been examined. Up to now a total of 6309 particles (average size 5 μm x 3 μm) have been observed. Part of them, which have nothing to do with the Tunguska event, is discussed elsewhere. For certain elements clear abundance peaks have been found in correspondence with the period of the Tunguska event. These results will be presented for the first time at the ACM 93 Conference.

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A TWO-PARAMETER SYSTEM FOR LINEAR POLARIZATION OF SOME SOLAR SYSTEM OBJECTS

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A two-parameter H, G magnitude system for asteroids has been adopted by IAU Commission 20 in 1985. By this system it is possible to predict magnitudes of asteroids at some phase angles for which there are no observations. The ubiquitous feature of asteroid magnitudes is the opposition effect (excluding the opposition spike) which seems to be well explained by the H, G system. We are currently working on an analogous system for the linear polarization of asteroids, planetary satellites and cometary comae. At least our preliminary results are encouraging and suggest that such a system can be found. It is effectively a combination of a few trigonometric functions multiplied by a constant b. The other free parameter is the inversion angle α_0 of polarization, and the other parameter b is clearly inversely proportional to the geometric albedo. This function also seems to predict polarization with a reasonable accuracy. We are careful in calculating all the errors and error envelopes associated with the predictions. A preliminary form and fits will be provided.

LIGHT SCATTERING BY SOLAR SYSTEM DUST PARTICLES IN THE DISCRETE-DIPOLE APPROXIMATION

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Electromagnetic scattering by irregular and porous dust particles has long been a challenging problem in various astronomical applications including such planetary system objects as cometary comae, asteroid regoliths and interplanetary particles. All these objects provide basic photometric and polarimetric data in a complementary way. In regoliths dust particles strongly interact between each other and surface roughness produces its own modulation. In cometary comae and interplanetary space there is no such interaction but the properties of dust particles almost certainly change as a function of either the distance from the cometary nucleus or from the sun. Only quite recently has the new advancement in the discrete-dipole approximation (DDA) made the problem of light scattering by various arbitrary shapes of dust partilces trackable. In the DDA method a particle is approximated by a large number (~ 10000) of small scattering elements (electric dipoles) which interact with each other. We have applied a new iterative method, called a quasi-minimal residual, to the resulting system of coupled linear equations in the DDA method. We study both the intensity and linear polarization of a single particle as a function of the effective size, porosity and the refractive index for various stochastic shapes of fluffy aggregates which we believe can model an actual dust particle. Some well known photometric and polarimetric features, such as the opposition effect and negative polarization seem to naturally follow from our computations.

The Kuiper Belt Comets

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The existence of a belt of comets in the outer solar system, called the Kuiper belt, has often been postulated to explain the origin of the short period comets. The reality of the belt seems likely following the discovery of the first Kuiper belt candidate, 1992 QB1. Crude lower limits on the population of the Kuiper belt can be established from the discovery: there are at least $N \sim 1440$ objects similar to 1992 QB1 in the belt, giving rise to a minimum mass of $2 \times 10^{-3}\, M_{Earth}$. Searches for other members of the Kuiper belt are in progress. Stronger constraints on the structure and population of the belt can only be obtained with detection of other belt members.

The Kuiper belt comets are likely to be primordial remnants of the planetesimal disk from which the solar system accreted, and as such should provide a wealth of information on early accretion processes. According to the current theories of evolution of cometary nuclei, the Kuiper belt comets are expected to possess mantles ("irradiation mantles") which are different from mantles of comets which have been heated by the Sun ("rubble mantles"). The Kuiper belt candidate 1992 QB1 and another newly found distant "asteroid", 5145 Pholus, display a distinctive red color unseen in other small bodies of the solar system which supports the existence of the irradiation mantle.

A Spin and Shape Model of 243 Ida

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Abstract

Earth-based photometric observations have been used to derive a reliable model of the asteroid 243 Ida prior to the Galileo flyby on 1993 Aug 28. The spin vector (with a 2-fold ambiguity) and the absolute rotational phases of the principal axes at the time of the encounter have been determined. A triaxial ellipsoid shape model has also been derived. Work on more detailed shape and albedo variegation maps are in progress at the time of abstract submission. The results are partly based on unpublished photometric observations by R.P. Binzel, M. Di Martino, Frueh, M. Gonano-Beurer, S. Mottola, D.J. Tholen, and W.Z. Wisniewski.

DUST PARTICLES BEYOND THE ASTEROID BELT - A STUDY BASED ON RECENT RESULTS OF THE ULYSSES DUST EXPERIMENT

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We present and discuss dust fluxes detected by the Ulysses dust experiment beyond the asteroid belt. Whereas dust fluxes detected inside about 2 AU are compatible with a population of interplanetary dust particles moving on low eccentric and low inclination orbits, different populations of particles are required in order to explain the data obtained beyond this region. A dust population on randomly inclined orbits can explain the rather flat and slightly increasing flux beyond approximately 2.5 AU. Within a distance of 1 AU around Jupiter periodic bursts of submicron sized dust grains were detected. An additional flow of high speed micron-sized particles on retrograde orbits is most probably of interstellar origin. We will concentrate our analysis on the discrimination of interstellar and interplanetary dust.

THE COMET OF 678 A.D. AS RECORDED IN THE ANGLO SAXON CHRONICLE.

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The Anglo Saxon Chronicle, which is the primary source for English historians, until now has been ignored by the astronomical community. The first of two score of astronomical phenomena mentioned is the Comet of 678 A.D. The Parker Manuscript (Worchester) states in its entry:

"In this year appeared the comet or star" (translation)

"HER OPIEWDE COMETA SE STEORRA" (original)

The Laud Manuscript gives a more precise and detailed account:

"In this year appeared the Comet or star in August and shone for three months each morning like a sunbeam." (translation)

"HER ATEOWEDE COMETA SE STEORRA ON AUGUSTE AND SCAN iii MOND AS AELCE MORGEN SWILCE SUNNE BEAM" (ORIGINAL)

This is the first of the eleven certain commentary references in the Anglo Saxon Chronicle. The anonymous contributor provided a strictly factual record of cometary sightings. Several can be checked with contemporary written sources. It is not so in this case

The Venerable Bede (673-735) makes no mention of it in his written works.

The Old English word 'cometa' comes from the Latin, which in turn came from the classical Greek Κομητης meaning 'long haired star'. It is a celestial body moving about the sun in an elongated elliptical or parabolic orbit and consisting (when near the sun) of a bright star-like nucleous surrounded by a misty light, and having a 'tail' sometimes of enormous length and usually directed away from the sun.

THE 8TH AND 9TH CENTURY COMETS: THOSE OF 729 A.D. AND MAY 892 A.D. AS RECORDED IN THE ANGLO SAXON CHRONICLE. Ernest George Mardon & Austin Albert Mardon, Antarctic Institute of Canada, Suite 907, 10136-100 Street, Edmonton, Alberta, Canada.

The annualist scribes who wrote the various versions of the Anglo Saxon Chronicle record observing two cometary phenomena, one in each century. They are as follows.

The Worchester Manuscript of the Chronicle for the 729 A.D. entry is brief:

"In this year the comet or star showed itself."(Translation)

"HER COMETA SE STEORRA HIENE OPIEWDE." (ORIGINAL)

The Peterborough Manuscript is different:

"In this year appeared two comets" (Translation)

"HER ATEWODEN TWEGAN COMETAN." (ORIGINAL)

This could the perihelion of the Comet. The Venerable Bede (673-735) has a more detailed account of this comet in his Ecceliastical History of the English People written in Latin and translated into Old English by order of King Alfred in the 9th century.

The Parker manuscript of the Anglo Saxon Chronicle 892 A.D. entry states:

"And that same year after Easter, about Rogation Days or earlier, appeared the star which in Latin is called 'cometa'; likewise men say in English that a comet is a long-haired star, because long beams of light shine, sometimes on one side, sometimes on the other." (Translation)

"AETEOWDE SE STERRA PE MON ON BOC LAEDON HAET COMET SAME MEN CWEPEP ON ENGLISC PAET HIT SIE FEAXEDE STEORRA." (ORIGINAL)

Chinese astronomers record that this comet appeared May 12th before dawn and moved in an easterly direction.

The Anglo Saxon Chronicle contains some forty other astronomical phenomena during the period 678 to 1114A.D.

THREE TENTH CENTURY COMETS: THOSE OF OCTOBER 905 A.D., AUGUST 975 A.D. AND AUGUST 995 A.D. AS RECORDED IN THE ANGLO SAXON CHRONICLE. Ernest George Mardon & Austin Albert Mardon, Antarctic Institute of Canada, Suite 907, 10136-100 Street, Edmonton, Alberta, CANADA.

The annualist scribes who wrote the various versions of the Anglo Saxon Chronicle recorded observing three cometary phenomena in the 10th century. They are as follows.

The Worchester Manuscript of the Chronicle for the 905 A.D. entry states:

"In that year a comet appeared on the thirteenth night before the Kalend of November." (Translation)

"HER COMETA AETEOWDE XIII K NOUEMBRIS." (ORIGINAL)

The Worchester Manuscript of the Anglo Saxon Chronicle entry for 975 A.D. states:

"In the harvest-time of the same year appeared that star known as "comet." (Translation)

"AND PA SONA ON PAM ILCAN GEARE ON HERFESTE AETEOWDE COMETA SE STEORRA" (Original)

The editor of the 1898 edition of the Anglo Saxon Dictionary used this quotation to define comet.

Other recorded observations of this comet in Europe, China and Japan, state that it was first seen on the night of August 3.

The Peterborough Manuscript of the Anglo Saxon Chronicle 995 A.D. entry states:

"In this year appeared the star called comet and Sigeric the archbishop (of Canterbury) passed away. (Translation)

"HER ON PISSUM GEARE AETEOWDE COMETA SE STEORRA AND SIRIC ARCB FORDFERDE" (Original)

THE 12TH CENTURY COMETS: THOSE OF FEBRUARY 1106 A.D.; JUNE 1110 A.D. AND MAY 1114 A.D. AS RECORDED IN THE ANGLO SAXON CHRONICLE. Ernest George Mardon & Austin Albert Mardon, The Antarctic Institute, Suite #907, 10136-100 Street, Edmonton, Alberta, Canada.

The annualist scribes who wrote the various versions of the Anglo Saxon Chronicle record observing three cometary phenomena in the 12th Century. They are as follows.

The Peterbough Manuscript of the Anglo Saxon Chronicle entry for February 1106 A.D. states.

"In the first week of Lent, on Friday forteen nights before the Kalend of March, appeared a strange star and for long stood afterwards was seen shining for a while each evening. The star made its appearance in the southwest and seemed to be small and dark, but the light that shone from it was very bright, and appeared like an enormous beam of shining light in the north-east. And one evening it seemed as if the beam was flashing in the opposite direction. Some said that they had seen other unknown stars about this time, but we cannot speak about these without reservation because we did not ourselves see them." (Translation)

"-AEFE AETYWDE AN UN GEWUNELIC" (PORTION OF ORIGINAL)

The Peterborough Manuscript of the Chronicle entry for June 1110 A.D. states:

"Later in the month of June a star appeared in north-east, its rays shining before it to the south-west. It was visable for many nights. Later on in the night, when it rose higher, it was seen moving away in a north-westerly direction." (Translation)

"DAER AEFT ON JUNIES MONDE AETYWDE AN STEORRA NORDAN EASTAN." (Original)

A German astronomer says this comet was visible from June 9 to June 30.

The Peterborough Manuscript of the Anglo Saxon Chronicle entry for May 1114A.D. states:

"In this year towards the end of May, a strange star was seen shining with a long tail of light for many nights." (Translation)

"DISES GEARES ON AEFTEWARD MAI WAESGESEWEN AN SELCUD STEORRA MID LANG AN LEOMAN MANEGE NIHT SCINENDE." (ORIGINAL)

This is the last cometary reference to be found in the Anglo Saxon Chronicle.

TWO 11TH CENTURY COMETS: THOSE OF APRIL 1066 A.D. AND 1097 A.D. AS RECORDED IN THE ANGLO SAXON CHRONICLE. Ernest George Mardon & Austin Albert Mardon, Antarctic Institute of Canada, Suite 907, 10136-100 Street, Edmonton, Alberta Canada.

The annualist scribes who wrote the various versions of the Anglo Saxon Chronicle record observing two cometary phenomena in the 11th century. They are as follows.

The Abingdon Manuscript and the Worchester Manuscript of the Anglo Saxon Chronicle entry for April 1066

"At that time, throughout England, a potent such as men had never seen before was in the heavens. Some declared that the star was a comet, which is called 'the long haired star': it first appeared on the eve of the festival of Letania Major, that is the eighth day before the Kalend of May (April 24) and shone every night for a week" (Translation)

"...sume men cwedon pa hit cometa se steorra waere, pone sume men hatad pone faexed steorran" (Original)

This comet was also reported by an Italian astronomer.

The Peterborough Manuscript of the Anglo Saxon Chronicle 1097A.D. entry states:

"Then after Michael mass, four days before the None of October, a strange star appeared. It was seen in the Southwest, shining in the evening and setting early. It was seen in the southwest and the trail of light that shone from it towards the South East appeared very long and was visable like this for almost a whole week. Many men said it was a comet. (Translation)

"aetywde an selcud steorra on aefen scynende and sona to setle gangende.... manige men leton pa hit cometa waere." (original)

SEARCH PROGRAMS FOR COMETS

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Although there are currently no professional search programs specifically designed for comets, comet discoveries are a significant by-product of the current search programs for near-earth asteroids. Some comets are also found in more general photographic sky patrols. With their emphasis on the opposition point and the ecliptic, the near-earth-asteroid patrols are clearly biased toward discovering short-period comets. During the past decade, for example, fully half of the new short-period comets have been discovered with the two Schmidt telescopes at Palomar, while the fraction of long-period comets discovered at Palomar is more like one out of four. Discoveries with the U.K. Schmidt at Siding Spring follow the same pattern but with about one-third the level of success. More than one comet out of three is a new short-period comet, a substantial increase from the one out of four or five that prevailed rather consistently for almost two centuries. The recent overall discovery rate of comets is considerably greater than in the years around 1960, after the first Palomar Sky Survey was completed, and even in the case of visual discoveries of long-period comets this increase is by a factor of two. Excluding the Kreutz sungrazing comets discovered with the SOLWIND and SMM coronagraphs, visual detections by amateur astronomers dominate among the comets with the smaller perihelion distances and consistently account for almost 90 percent of discoveries with perihelia inside the orbit of the earth. Although visual detections may seem rather haphazard, many amateur astronomers do conduct their searches systematically, special consideration being given to the optimal phase of the moon for morning versus evening discoveries. Reliance on visual detections means that only one long-period comet out of seven or eight is being found more than three months before perihelion passage, even for perihelia out to the orbit of Mars. In addition to the obvious point of the short notice one has in order to prepare for making interesting new physical observations of a potentially bright comet, the limited time span usually makes it impossible to decide whether a comet is likely to be "new" or "old" in the Oort sense, a factor that affects how bright the object is likely to become. Furthermore, even if there is a long observed arc after perihelion, the presence of nongravitational forces can adversely influence the decision. It is therefore highly desirable to discover long-period comets of small perihelion distance when they are far enough away that a true determination of the "original" reciprocal of the semimajor axis can be reliably determined. Thought should therefore be given to an appropriate extension of the process by which professional discoveries of comets are made.

ORBITS DETERMINATION AND STAR CATALOGUE ERRORS

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We obtain Ceres orbit taking into account all perturbations and applying correction of phase effect to observations. More than 3000 observations have been used and the results agree with other determinations.

We have investigated also the influence of systematic errors of star catalogue on the observations and its effect on final elements.

To that aim, a simulation procedure has been applied to Ceres observations, including different laws for error of star catalogue versus spherical coordinates.

The best relations have been applied to real observations of Ceres and other asteroids, in order to obtain elements and star catalogue corrections.

Preliminary results of these calculations are presented.

ORBITAL EVOLUTION OF DUST PARTICLES NEAR J/J+1 RESONANCES WITH THE EARTH

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We have performed a numerical study of the orbital evolution of interplanetary dust particles in the region of the first order outer resonances with the Earth. With a systematic approach, based on a large number of simultaneous numerical integrations, we have explored: 1) the location of stable resonance trapping regions in the $e-\tilde{\omega}$ plane 2) the long term dynamical behaviour while in resonance 3) the mechanism forcing the escape from the resonance. The physical model is basically a seven–body problem, the sun, the five major influencing planets (Venus, Earth, Mars, Jupiter and Saturn), the dust particle. As numerical method for solving the equations of motion we have adopted the RA15 integrator by Everhart [1].

The choice of the $e-\tilde{\omega}$ plane as representative of the six–parameter orbital phase space in studying the resonant capture of dust grains was motivated by the strong dependence of both the resonant and dissipative (P–R and wind drag) perturbations on the eccentricity of the particles and by the relation existing between the angle variable $\tilde{\omega}$ and the mutual geometrical configuration of the particle orbit with respect to the Earth's orbit, in particular for low inclination orbits. Our results show how in each j/j+1 resonance the maximum probability of capture occurs in correspondence to eccentricity values for which the dust grain's and planet's orbits begin to cross. Moreover the location of the trapping regions is shifted toward smaller eccentricities with increasing j. As a consequence low–eccentricity dust particles are captured more frequently in high–j resonances.

To gain more insitgh in the long term resonant behaviour of dust grains, we have investigated how the trapping time t_T varies for different j/j+1 resonances. Inside the stable trapping regions of each resonance we have selected sets of initial conditions to be used for integrating test particle orbits. We follow the orbital evolution of these particles until they escape from the resonance. To speed up the calculations, we have integrated the orbits by directly introducing in the equation of motion the position vectors of the five perturbing planets as obtained from the Richardson–Walker numerical simulation of the motion of the full planetary system [2]. Preliminary results show a decreasing trend of the trapping time for higher values of j. This can be explained by taking account of the increased probability of deep close approaches for low–eccentricity particles. As pointed out before, these particles are most easily trapped in high j resonances. Indeed we have observed in all our simulations how the escape from resonance is correlated to a series of close encounters with the Earth. Close encounters remove dust particles from resonances and in most cases force them into a highly chaotic orbit characterized by random impulsive changes of the orbital elements.

REFERENCES: [1] E. Everhart, in *Dynamics of Comets: Their Origin and Evolution* (Reidel, Dordrecth, 1985), p. 185; [2] Marzari F., Weidenschilling S.J., Fabris M. , Vanzani V. (1991) *LPSC XXII*, 861.

Is The Perihelion Asymmetry In The Nongravitational Force Acting On Comet 1960II (Burnham) Due To Its Passage Through The Taurid Stream?

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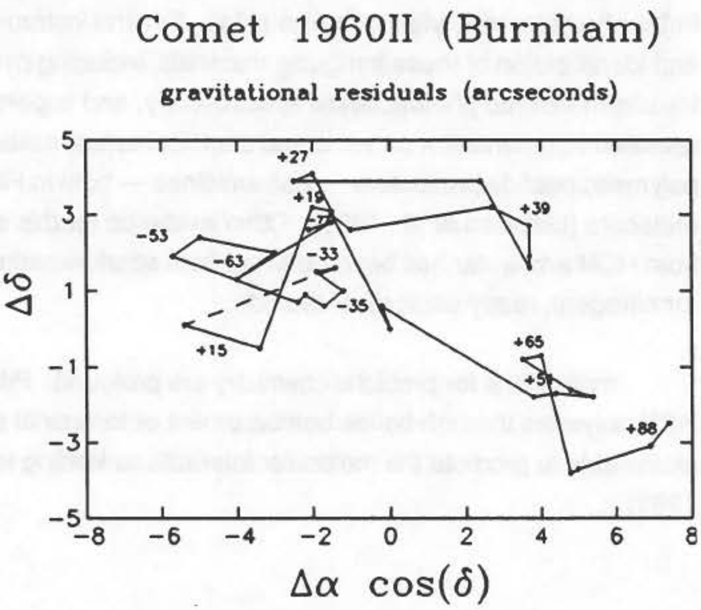
Comet Burnham has been cited (Marsden, 1969) as unique among Oort cloud comets in having high-precision observations which exhibit a large, systematic trend in the gravitational orbit residuals. Over a six-month interval, 37 individual measurements by Roemer, *et al.* (1966), illustrated in the accompanying figure, showed a minimized mean residual of $3''.06$ when fit to a gravitational orbit. The gravitational solution for the original value of the reciprocal semimajor axis is $1/a = -135 \pm 23$ in units of $10^{-6}\mathrm{AU}^{-1}$ where the uncertainty quoted is the formal measurement error. Comet 1960II is also distinguished as one of only seven dynamically new comets which have original gravitational orbits that are nominally hyperbolic at a level $\geq 5\times$ the formal measurement error (Matese, *et al.* 1991, 1992). In these references it was demonstrated that this hyperbolic family uniquely correlates with orbits that preferably have small perihelion distances *and* move in a retrograde sense to the planetary motion. It was argued there that the physical explanation for this correlation is the catalytic enhancement of nongravitational forces due to outgassing of volatiles.

Whipple (1950) recognized the importance of the rocket-like forces on a comet nucleus when he formulated his conglomerate model. A standard model of these nongravitational forces has emerged which embodies reactive forces that are symmetric about perihelion (Marsden, 1968, 1969; Marsden *et al.* 1973). However there is a growing body of evidence that these forces may be *asymmetric* about perihelion (Yeomans and Chodas 1989; Rickman *et al.* 1991). Since the nongravitational force parameters deduced by the two approaches can be quite different, it becomes crucial to determine which approach is a better representation of reality if one hopes to use the parameters to characterize the physical properties of comets.



To date, no asymmetric model of Comet 1960II has been constructed. We present arguments here which indicate that an asymmetric model of nongravitational forces will yield a better fit to the orbit and that the onset of peak outgassing will be delayed well beyond perihelion. These results are visually suggested in the figure in which the gravitational residuals are dated relative to perihelion passage and connected sequentially by straight lines. One observes that the residuals random walk during the initial phases. The large systematic trend mentioned by Marsden only begins well beyond perihelion.

We have found that Burnham passed through the Taurid stream in the interval 16-19 days subsequent to perihelion during which the relative velocity of the comet and meteoroidal stream material was ≈ 80 km s^{-1}. We will argue that there is a causal link between the stream passage and the onset of substantial nongravitational forces. Meteoroidal impacts can be expected to create craters up to 1 meter in size, exposing the underlying volatiles and releasing any subsurface pressures which may have built up as the mantle formed. Related observations of the intrinsic light curve of Comet 1960II will also be presented.

CYANIDE POLYMERS ON SOLAR SYSTEM BODIES

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Hydrogen cyanide polymers — heterogeneous solids ranging in color from yellow to orange to red to black — may be among the organic macromolecules most readily formed within the solar system. The non-volatile black crust of comet Halley, for example, might consist largely of such polymers (Matthews and Ludicky, 1992). It seems likely, too, that HCN polymers are a major constituent of the dark, C≡N bearing solids identified spectroscopically in the dust of some other comets, on the surfaces of several asteroids, within the rings of Uranus and covering the dark hemisphere of Saturn's satellite Iapetus (Cruikshank, et al. 1991). HCN polymerization could account also for the yellow-orange-red coloration of Jupiter and Saturn, as well as for the orange haze high in Titan's atmosphere.

Studies of these polymers show that a yellow-brown powder can be extracted by water and further hydrolyzed to yield α-amino acids. Several instrumental methods used for the separation and identification of these intriguing materials, including pyrolysis mass spectrometry, Fourier transform infrared photoacoustic spectroscopy, and supercritical fluid extraction chromatography revealed fragmentation patterns and chemical functionalities consistent with the presence of polymeric peptide precursors — polyamidines — both in HCN polymers and in the Murchison meteorite (Liebman et al., 1993). Other evidence for this direct route to polypeptide formation from HCN and water has been obtained from spark experiments involving methane and ammonia (or nitrogen), ready sources of cyanide.

Implications for prebiotic chemistry are profound. Primitive Earth may have been covered by HCN polymers through bolide bombardment or terrestrial synthesis, producing a proteinaceous matrix able to promote the molecular interactions leading to the emergence of life (Matthews, 1992).

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Liebman, S. A., Pesce-Rodriguez, R. A., and Matthews, C. N. : 1993, *Adv. Space Res.*, in press.
Matthews, C. N. and Ludicky, R. A. : 1992, *Adv. Space Res.* 12, (4) 21
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Ecliptic north–south asymmetries in the natural meteoroid population as sampled by LDEF

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It is generally assumed that the time averaged meteoroid influx to the Earth from the zodiacal dust cloud and the meteoroid sporadic background is symmetrical with respect to ecliptic north and south. However, localised asymmetries at the Earth's orbit due to components from passing comets and well known meteor streams may be expected. Work on the Long Duration Exposure Facility (LDEF) shows that there is a pronounced ecliptic north bias (north to south ratio of around 1.7) from large interplanetary particles (diam 30μm). By considering the LDEF orbital history, we find that a $+6°$ shift in the median position of the ecliptic latitude distribution of incoming meteoroids is sufficient to explain this asymmetry. We identify possible sources for the observed asymmetry, these being cometary sources that pass within 0.1 AU of the Earth's orbit, high activity meteor streams, or single large atmospheric fragmentation events which subsequently encountered the spacecraft.

The Comet-Asteroid Transition

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The Near-Earth asteroids are in orbits that are dynamically unstable over the age of the solar system. There must be a steady source or sources supplying this population which are expected to be the main asteroid belt and the short period comets. Dynamical studies and observations of the physical properties of Near-earth asteroids combined contribute to advancing our understanding of the nature and evolution of the small bodies in the near-Earth environment and ultimately the compositional differences in the initial reservoirs from which the asteroids and comets formed.

Some objects are discovered and designated as asteroids only to reveal that they are indeed comets as evidenced by their dust and gas comae, e.g. 1986 TF = Comet P/Parker-Hartley (IAUC 4752). Conversely, asteroid 4015 1979 VA is the same object as Comet P/Wilson-Harrington (1949 III) (IAUC 5585), but no evidence of a gas or dust coma was observed when it was discovered in 1979. Other objects are found in very unstable, Jupiter-crossing orbits with no evidence of cometary activity, e.g. 5335 1991 DA and 5145 Pholus, 944 Hidalgo, 3552 Don Quixote.

Physical observations of planet-crossing asteroids to determine whether they have weak dust and/or gas comae are necessary to determine which asteroids evolved from comets. If no evidence of a coma is observed, it does not eliminate the possiblity that the object evolved from a comet, it could mean that it is currently dormant. If an object has a high albedo and strong absorption bands in the UV, visible and near-infrared spectral regions, it is probably derived from evolution of orbits from the inner regions of the main asteroid belt, as such characteristics are a reasonably reliable signature of the inner asteroid belt.

It is important to continue to make observations of known cometary nuclei to understand their range of physical properties, to understand their evolution as low activity, dormant or extinct nuclei, and to search for a diagnostic physical signature of a cometary remnant. Physical observations coupled with dynamical studies will reveal the compositional differences between the different reservoirs in the solar nebula from which these bodies formed.

ON THE DUST CLOUD IN THE COMET'S HEAD AND ITS ROLE IN FORMING THE PHOTOCENTRE SHIFT PHENOMENON. Yu. D. Medvedev, Institute of Theoretical Astronomy, 10, Nab. Kutuzova,191187 Saint Petersburg, Russia.

Within the head of a comet there exists the point of equilibrium around which the dust is accumulated. The point is located on the comet-Sun line and is stable with respect to the motion of a dust particle along this line. The model computations support this theoretical conclusion. The estimation of brightness of the dust cloud and the comparison with that one of the comet nucleus have been done.

The simple formulae have been deduced for the distance of this point from the center of the comet nucleus in terms of the gas productivity and the heliocentric radius of the comet. The computed values of this distance for the P/Halley in the 1985–1986 apparition are equal to 180 km and 990 km for the preperihelion and postperihelion motion of the comet correspondingly. The last of these values is in agreement with the observed value of the post-perihelion photocentre shift of the P/Halley. As for the first one, it is small and is difficult to observe.

NUCLEUS PROPERTIES OF P/SCHWASSMANN-WACHMANN 1

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ABSTRACT

Time series photometric measurements are presented of comet P/Schwassmann-Wachmann I at a heliocentric distance of 5.886 AU when the comet possessed an extensive coma. The lightcurve shows a modulation caused by the rotation of the nucleus. The rotation period is considerably shorter than the 5 day period found by Whipple (1980) and we find substantial evidence that the nucleus may be in a complex spin state characterized by two periods 14.0 and 32.3 hrs. Models of the rate at which the rotational lightcurve range decreases as a function of the amount of coma in the aperture has determined that the projected maximum to minimum axis ratio of the comet is 2.6 and that the product of the albedo times the rotationally averaged nucleus radius size, $p_r.R_n^2$, is 9.5 +/- 0.3 km^2. Assuming a minimum geometric albedo of p_r = 0.04, the maximum projected average nucleus radius is R_n = 15.4 +/- 0.2 km, which is only 44% of the size estimated by Roemer (1966). However, using the albedo determined by Cruikshank and Brown (1983) of p_r = 0.13, the nucleus radius is only R_n = 8.6 +/- 0.1 km. Because of the unknown nucleus orientation, these will be upper limits to the nuclear size. It appears that the nucleus of P/Schwassmann-Wachmann I is not the large nucleus that it has been believed to be for nearly 40 years.

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Mass Loss Limits from 5145 Pholus

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Both ground-based and Hubble Space Telescope (HST) images of the Chiron-like asteroid 5145 Pholus were obtained in an effort to search for cometary activity just past the perihelion time in 1991 September. Ground-based observations were made with the University of Hawaii 2.2m telescope on UT 1992 Jan 31 (R filter; 3200 sec) and with the Cerro Tololo Interamerican Observatory 4m telescope on 1992 March 7 (BVRI filters; 800 sec) at heliocentric distances of 8.71 and 8.72 AU respectively, under conditions of good seeing. HST data were obtained on 1992 April 28 with the Planetary Camera (F555W, F785LP filters; 2400 sec total exposure time through the F785LP filter and 900 sec total through F555W). Neither the ground-based nor HST images show signs of coma. We will discuss the restoration of the HST images using the Lucy-Richardson technique and discuss how the data were compared to stellar profiles for both the ground-based and HST images. We will present models for limits on steady-state dust production and possible bound coma on Pholus and compare this to dust production on Chiron and limits for other extinct comet candidates which have been observed.

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produktion rates of Comet P/Halley

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We reports the results of ground-based photometric observations of comet P/Halley between 1986 February 24 and April 16. The measurements were obtained in the IHW-filter system (H_2O^+, red-continuum, C_2, blue-continuum, CO^+ and CN) each with 9 diaphragmas (11".32, 18".23, 28".9, 45".4, and 1'.19, 1'.917, 3'.014, 4'.764, 7'.525). This great number of diapraghmas ise useful for improving the parameters of Haser models.

PHOTOMETRY, PHASE CURVE AND SPIN VECTOR OF 675 LUDMILLA

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Asteroid 675 Ludmilla has been observed during two apparitions (1965 and 1973) and its synodical period is 7.717 hours. The lightcurves obtained at Kharkov Observatory in 1991 and 1993 oppositions are presented. These observations allowed us to obtain the phase relation and determine the H and G values of the HG-magnitude system. Using all available lightcurves we have determined the sidereal period, sense of rotation, pole and triaxial ellipsoid model of Ludmilla.

532 HERCULINA: PHOTOMETRY, POLARIMETRY AND MODEL

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The lightcurves of the asteroid 532 Herculina obtained at Torino Observatory (1982), ESO (1988) and Kharkov Observatory (1992) are presented. On 5 June 1992 the variation of light polarization was also observed.

Herculina has very unusual lightcurves. They exhibit one pair of extrema during some oppositions and two pairs of extrema during the rest. These variations are within the rotation cycle of about 9.4 hours. The model which explains such strange behaviour of this asteroid is presented.

PERIODS OF TWO NEAR-MARS ASTEROIDS: 626 NOTBURGA AND 2078 NANKING.
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Photoelectric observations of the near-Mars asteroids 626 Notburga and 2078 Nanking were carried out during 1992 oppositions. The synodic rotation periods about 19 hr, 6.56+/-0.01 hr, and the lightcurve amplitudes of 0.20 mag and 1.0 mag were determined for Notburga and Nanking respectively. Observations show that asteroid 2078 Nanking has a very elongated shape with a/b = 2.5.

SECONDARY RESONANCES INSIDE MEAN MOTION COMMENSURABILITIES.

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We study the secondary resonances between the libration frequency of asteroids at mean motion commensurabilities with Jupiter and one of the two other basic frequencies of the Sun-Jupiter-asteroid system. For each of these two fundamental frequencies, we locate the secondary resonances of low order that appear at low values of the eccentricity of the asteroids. Integrating numerically the trajectories of the averaged system, we also draw the shape of the secondary resonances and show the extent of the chaotic zone on surfaces of section.

SECULAR RESONANCES IN THE 2/1 KIRKWOOD GAP. Michèle Moons, Noriaki Watanabe, and Jacques Henrard, Département de Mathématique, FUNDP, 8 Rempart de la Vierge, B-5000, Namur, Belgium.

We investigate the three-dimensional long-period dynamics inside the 2/1 Kirkwood gaps by means of a semianalytical perturbation method. Secular resonances are identified and localized. In particular, a nodal secular resonance with the frequency associated with the node of Uranus may provide an explanation for the peculiar orbit found by Wisdom, which starts at low eccentricity and inclination, meanders to high inclination and moderate eccentricity, and ends up at high eccentricity and low inclination.

A SECULAR INTEGRATOR FOR ASTEROID FRAGMENTS

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This work is a byproduct of the proper element program by A. Lemaitre and A. Morbidelli. The Hamiltonian of the problem (massless asteroid perturbed by Jupiter and Saturn) is averaged with respect to the mean longitudes of both asteroid and planets, and is coded in a new grid directly in Arnold action-angle variables. These are the most suitable ones in order to take into account the strongly non linear dynamics related to the motion of the argument of perihelion, which is dominant at large inclination. Only the three main terms, corresponding to the three main secular resonances ν_5, ν_6, and ν_{16} are retained in the perturbation. The averaged equations of motion are integrated directly in action-angle variables. Therefore this secular integrator turns out to be very fast (30 seconds for 1 million years on a HP710 work station). However, due to the simplifications of the model, the results are qualitative. So, this secular integrator is very suitable for statistical studies on the behaviour of thousands of fictitious objects, such as simulated fragments of real steroids, in order to study the dynamical mechanisms of meteorite transport. We plan to complete this secular integrator with a Monte-Carlo simulation of the effects of close approaches with the inner planets.

Detection of polycyclic aromatic molecules in comet P/Halley

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Spectra of the inner coma of P/Halley were obtained during the approach session of Vega 2 on March 9, 1986. The instrument, called three-channel spectrometer or TKS, covered the 275-710 nm range. It produced a spectroscopically-resolved scanning of the inner coma at distances less than 40 000 km. The scientific data are presented under two forms :

i) spectra at various projected distances p, i.e. distances between nucleus and optical axis

ii) radial profiles of given emission intensities at selected wavelengths, in the 40000-400 km distance range.

The spectra show the molecular emissions of OH, NH, CN, C_3, CH, C_2 and NH_2 and the continuum intensity scattered by dust grains. This emission becomes rapidly more intense than the molecular bands with decreasing projected distance parameter p. For instance, when p = 1000 km, the scattered intensity is ten times brighter than the CN emission. At distances shorter than 1000 km, the residual spectrum after subtraction of the intense solar continuum, shows the presence of two new spectral features : an isolated band at 323 nm and a broad band with four peaks at 347, 356, 364 and 373 nm. The intensity of these bands rapidly increases with decreasing distance to the nucleus. It follows approximately a 1/p law, which implies that the molecules responsible for the emission are either parent-type molecules or are released by grains of the dust flow.

A search for candidates being possibly responsible for the new emission at p< 1000 km shows that the spectra of CN, OH, CO_2^+ and H_2CO cannot explain the spectral features and the radial variation of the detected bands. Since the existence of polycyclic aromatic compounds was suggested following the identification of an X-CH vibration band at 3.2-3.5 micrometers in Halley's IR spectrum, we compared the UV laboratory spectra of PAH having 2 and 3 benzenic rings with our cometary spectra. A good fit was obtained at 323 nm with the fluorescence spectrum of jet-cooled naphtalene (Beck et al., 1981, 74, 1, 43-52). In the case of the broad-band at 342-375 nm, a very good agreement was found between the cometary spectra and the fluorescence spectrum of phenanthrene, (Karcher et al., 1985, Spectral Atlas of Polycyclic Aromatic Compounds, D. Reidel Publ. Co.).

In conclusion, we can securely suggest the identification of naphtalene and phenanthrene in Halley's comet. It may also be suggested that the unidentified features at 321.9 and 323.2 nm detected in comet Austin by Valk et al., (Ap. J., 1992, 388, 621-632) might be due to naphtalene. The detection of two specific polycyclic aromatic molecules in Halley's comet supports the idea of an analogy of composition between cometary material and interstellar matter. It has important implications in the scenario scheme of the earlier solar system formation period.

An interpretation of P/Halley's photometry at 5 AU pre-perihelion

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Abstract

Belton et al.'s original spin model for P/Halley [1] was successfully tied in with photometric observations at 8 AU pre-perihelion when the comet was rather inactive [2,3]. Most of the observed light-curve near 8 AU is adequately explained by light scattered off a homogeneous nucleus, spinning as described by Belton et al. [1] and with the shape determined by Sagdeev et al. [4]. Superimposed on this variation are transitory and periodic bursts of coma activity that probably originate in an active region near the small end of the nucleus (area 1, Belton et al. [1]). This region is probably identical to one of the most active areas found in the March-April, 1986, time frame.

We present the results of the comparison of the spin model with photometric observations at 5 AU pre-perihelion. Special consideration will be given to the active areas, in particular to active area 1.

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Is P/Schwassmann-Wachmann 2 really a simple rotator?

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Abstract

P/Halley is the only comet known with a well established complex rotation [1]. Extensive light-curve coverage of active comets far away from the Sun when their activity is not dominant has only been done for a few comets. Karen Meech (Meech et al. [2]) used a new method to account for coma contribution to the reflected light of the nucleus of P/SW 1 and the analysis of her light-curve data strongly suggests that its nucleus might also be in an excited state of energy. If these two comets show complex spin states, why do other comets not show the same behavior? Is it due to different behavior of outgassing from the nucleus (e.g. due to structure of the crust, number of vents, dynamical age) or is it just due to the poor light-curve coverage of comets and/or our methods of periodicity analysis? Some of these questions will be addressed in this paper, in particular using the recent observations of P/SW 2. The photometric data of P/SW 2 near aphelion by Luu and Jewitt [3] were re-analyzed with special emphasis on multiple period search. Results of this analysis will be presented at the meeting.

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ORBITAL UNCERTAINTIES OF SINGLE–APPARITION ASTEROIDS

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We have applied the two–body linear approximation of our Bayesian orbital uncertainty analysis (*Icarus*, in press) to observations of more than 10,000 asteroids observed at one apparition only. We required five or more observations, and assigned 1.0–arcsecond standard deviations to both R.A. and Decl. All published high–precision observations were considered, without regard to their quality, and the epochs of the orbital elements were chosen to be midway between the first and last dates of observation. The entire analysis took only 25 minutes on a 4.2–MFLOP computer, thanks to the simplicity and efficiency of the two–body approximation. The final database included the epoch, number of observations, observational arc, orbital elements and their 1–σ uncertainties, several orbital quality metrics, and the covariances of the orbital elements.

The cross–correlations among the miscellaneous database items were then investigated. The so–called leak metric (an orbital quality metric: Muinonen and Bowell, *op. cit.*) correlated slightly with the number of observations and significantly with the observational arc. We found an empirical law of the form $\theta \approx 5T_{\mathrm{arc}}^{-2}$ (leak metric θ in radians, observational arc T_{arc} in days) for single–apparition main–belt asteroids. The law is typically correct to an order of magnitude, which we consider to be intriguingly good, though it fails to describe the quality of Earth–crossing and distant asteroid orbits. Imitating Poisson statistics, we then included the number of observations N_{obs}, and empirically obtained $\theta \approx 6T_{\mathrm{arc}}^{-2}/\sqrt{N_{\mathrm{obs}}-3}$ (units as above), valid for single–apparition main–belt asteroids to within a factor of three.

LIGHT SCATTERING BY SOLAR SYSTEM DUST: DOES THE THEORY EXPLAIN THE OBSERVATIONS?

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We review recent theoretical, observational, and experimental developments in the optical photometry and polarimetry of small solar system bodies and interplanetary dust, paying special attention to the opposition effect (nonlinear brightening at small phase angles) and the reversal of linear polarization (a change in the predominant plane) toward opposition. Coherent backscattering has been invoked to explain both of the aforementioned phenomena, though shadow–hiding also contributes to the opposition surge. In analyzing the observations and experiments, we subject the coherent backscattering mechanism to critical examination. The mechanism is based on Maxwell's electromagnetic equations, but it is not currently possible to solve the equations rigorously for arbitrary dust particles or regoliths. We are therefore limited to qualitative interpretation of the observations and experiments, and must leave quantitative interpretation as a future goal.

Polarimetry of Asteroids

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Why do asteroids, comets and other airless bodies in the solar system show similar phase angle α dependences of linear polarization? That is, in $\alpha \leq 20^\circ$-25°, the polarization takes the negative branch with the minimum depth at about $\alpha=10^\circ$. Beyond the inversion angle of $\alpha = 20^\circ$-25°, the polarization increases with a constant slope and reaches the maximum value at nearly $\alpha = 90^\circ$.

Taking into account the scattering of light by large rough particles and small aggregates in the regolith on the surface of asteroids, a phase function of linear polarization is examined. Our calculated results will be compared with the recent data of visible polarimetry of 4179 Toutatis observed at 7 channels between the wavelengths of 3600A and 7600A . Toutatis was favourable to observe at higher phase angles(see figure 1).From a quick look of our measurements, it is found that a peak of polarization expected at $\alpha = 90^\circ$ cannot be seen from the data at the available phase angles less than 101°. Further details of our calculated results, as well as polarimetric data, will be reported.

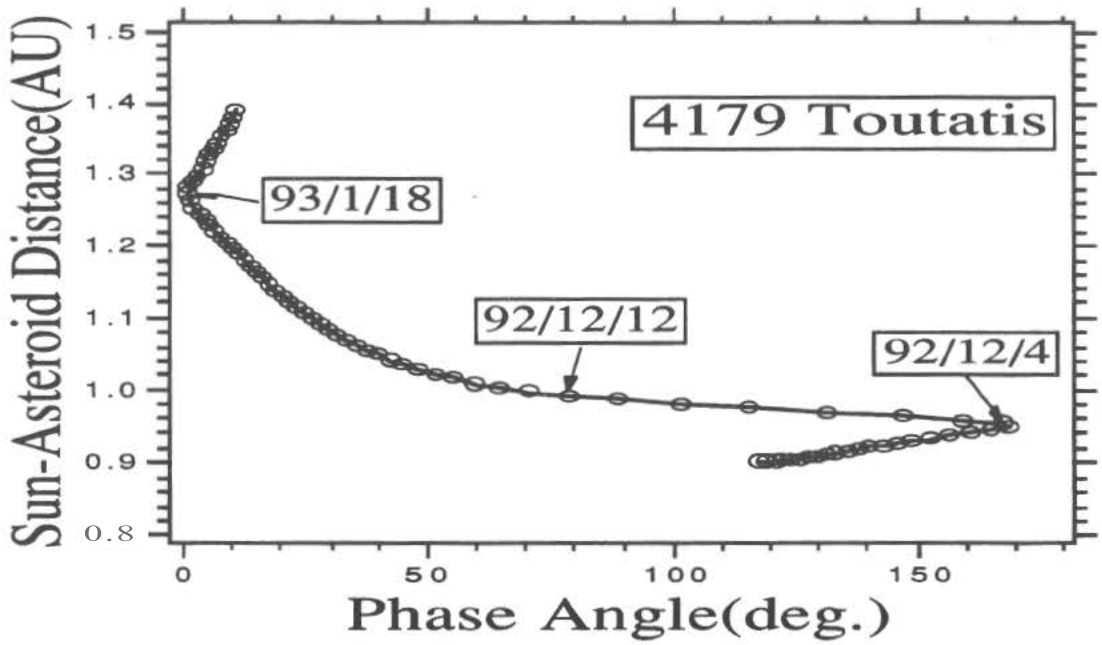

Fig.1. A relation of a phase angle and sun-asteroid distance for 4179 Toutatis. Each circle indicates the date.

Methanol in Recent Comets: Evidence for Two Distinct Cometary Populations

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The abundance of methanol has now been measured for six comets: two are dynamically new, three are short-period comets, and one is a long period comet. The sampled comets exhibit two distinct values for the relative abundance CH_3OH/H_2O (Table I). The simplest interpretation is that the two values are cosmogonic, i.e. that the comets represent two populations that formed in different regions of the solar nebula, or accumulated at different times during the collapse phase.

Current models for the dynamical evolution of cometary orbits argue that two reservoirs contribute to the current ensemble of short period comets (1, 2). The first reservoir has two parts: an outer Oort cloud (~10^{12} comets at ~10^5 AU) and an inner Oort cloud (~10^{13} comets at ~10^4 AU). The inner Oort cloud consists of comets formed in the Uranus-Neptune region of the solar nebula and ejected from the inner solar system by the growing proto-planets. The outer Oort cloud is populated from the inner Oort cloud by galactic perturbations, thus we expect these comets to be identical in nature. The second reservoir, the so-called Kuiper Belt (~10^8-10^9 comets at ~100 AU), consists of comets that formed beyond the orbit of Pluto and have remained there ever since. The existence of the Kuiper Belt is invoked to explain the observed excess number of low inclination short period comets (1), however, Shoemaker has argued that high inclination short period comets may only appear to be deficient in number because of systematically larger perihelion distances, owing to the Tisserand invariant. The orbital inclination of a given short period comet is not a definitive indicator of its origin.

Since two of the three comets with high (~5%) methanol abundance are dynamically new, we associate high methanol abundance (Population I comets) with formation in the Uranus-Neptune region of the solar nebula. The third is P/Swift-Tuttle which is now a short-period comet. However, its methanol abundance suggests that it once was an Oort cloud comet, that must have been captured long ago since it has resided in the inner solar system long enough to generate a meteor stream. The three comets with low (~1%) methanol abundance (Population II) may have originated elsewhere, possibly in the hypothetical Kuiper Belt. The observed compositional dichotomy is also consistent with a <u>single</u> formation region, if radiation processing of pre-cometary ices varied strongly with time in the nebula. Then late-forming comets may contain less methanol than those formed earlier in the nebular collapse phase. Measurements of methanol and related species in additional comets would test the composition and relative numbers of type I and II comets, for comparison with radiation chemistry models and predicted orbital statistics(1, 2).

Table 1. The Methanol Abundance in Recent Comets.

Comet	Period	Inclination	Methanol/water(%)	Ref
Wilson 1987VII	New	147	6 ± 1	(3)
Austin 1990V	New	59	5 ± 2	(4, 5)
P/Swift-Tuttle	130 y	114	6 ± 1	(6, 7, 8)
P/Halley	76 y	162	1 ± 1	(3, 9, 10)
P/Brorsen-Metcalf	70 y	19	1 ± 1	(4)
Levy 1990XX	15,000 y ?	132	1 ± 1	(4, 5)

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Oblique Impact Disruption: Velocity and Spin Distribution of Fragments

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Laboratory experiments of impact disruption have been performed to simulate large scale collisions among asteroidal bodies. The distribution of velocity and rotational frequency of fragments are the fundamental outcomes from collisional disruptions. Recently, we made experiments of basalt and alumina disruptions with incident angle of 60° to the surface, and of gypsum disruption with normal incidence (Nakamura and Fujiwara 1990, Nakamura, Suguiyama, and Fujiwara 1991). It was shown that the fragment velocity in the center of mass system (CMS) is proportional to ~–(1/2~1) power of the fragment size. At a given size of the fragment, the CMS velocity ranges over an order of magnitude. The velocity of basalt fragments from less oblique impact may give systematically larger values than those of the others.

We have performed further analysis of the series of disruption experiments of the basalt target. The incident velocity was fixed at about 3.3 km sec^{-1}, whereas, the incident angle was varied from 90° to 30° to the surface. The CMS velocity and rotational frequency of fragments were determined. The overall feature of the size-velocity and -frequency relation are similar to the previous ones; smaller fragments have in general higher CMS velocity and frequency. However, it was found that the largest fragments from highly oblique shots had velocity smaller than those from nearly normal shots.

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Gas drag forces on fractal aggregates

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Gas drag force is an important quantity to study the dynamical behavior of a grain in several environments under low gas density, such as in the protoplanetary disk or around the nucleus of comet. Baines et al.(1965 M.N.R.A.Soc.) derived an analytic formulae for the resistance to a spherical grain moving through gas when its radius is smaller compared with a mean free path of ambient gas. They have found that the resistance is proportional to the cross-section of a moving grain. Recently, many observations and theories suggest the existence of irregularly shaped grains in space. Therefore, we have to examine the gas drag forces on such fluffy grains. We apply the fractal aggregate model for fluffy grains, which are produced by simple coagulation process of elementary particles, i.e. ballistic particle-cluster aggregation (BPCA) and ballistic cluster-cluster aggregation (BCCA). The difference in the structure of the aggregates is described by a fractal dimension D. Since it is impossible to calculate the cross section of irregularly shaped aggregate and the mean momentum transfer by collisions with gas molecules for aggregate analytically, we have performed Monte-Calro simulations to estimate them. If the gas molecules are scattered by the aggregate in a similar way to the case of a compact sphere, it is found that the gas drag force is proportional to the cross section for the aggregate as that for sphere. It is found furthermore that gas drag force is more effective for fractal aggregate due to its larger cross section compared with a compact sphere with the equivalent mass. Our results strongly suggest that the aerodynamical behavior of fractal grains is controlled by its fractal dimension and consequently it becomes quite different from that of a compact sphere.

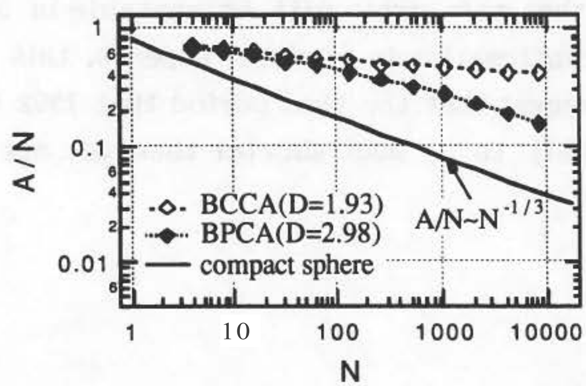

Fig.1

Cross section/Mass vs. number of elementary particles for BPCA and BCCA

Exponential Growth of Round-Trip Error and Instability of Orbits of Small Bodies in the Outer Solar System

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Exponentially growing behavior of the round-trip (RT) error in a closure test of numerical integration for orbits of comets and come-like bodies was examined in relation to the time scales of their orbits becoming chaotic and unstable. For the majority of the orbits of about 160 SP comets that we integrated for 4400 years, the relative RT error for each of Kepler elements increased approximately exponentially from a very small value (say, 10^{-22}) to the order of unity within 1000-2000 years; this period of time was found to be nearly the same as the capture/ejection time scale for the SP comets. Similarly, as a result of 0.1- 0.2 My integration, we found that the error growth time scale for the orbits of giant comet-like objects such as Hidalgo, Chiron, and Pholus (5145,1992AD) is consistent with the time scale in which those orbits change substantially from the present ones.

If this parallelism between error growth and orbital change is valid for the objects with much slower orbital evolution, it is expected that long-term orbital stability/instability of an object can be discussed to some extent, without performing direct numerical integrations for a very long period of time. We here applied this proposed conjecture to the orbital evolution of 1992 QB1, which travels outside the orbit of Pluto with an eccentricity as small as those of outer planets: a 2.4 My numerical integration of this orbit (IAUC No.5684) toward the past did not show any appreciable changes in the orbital elements. An extrapolation of the RT error growth curve of 1992 QB1 obtained from 0.1 - 0.4 My integrations seems to indicate that this orbit will be unstable in 5-10 My. Although this value needs further confirmation in various respects, this result, if taken at its face value, may suggest that the time period that 1992 QB1 had stayed in the present orbit is likely to be much shorter than the age of the solar system.

NEAR–EARTH ASTEROID GROUPS

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ABSTRACT. A statistical examination of fine structure in the near–Earth object system was carried out and revealed the presence of several asteroid groups, in each of which the members had closely similar orbits. Two strong groups (each with $\gtrsim 12$ known asteroids) appear to be associated with Comets Giacobini–Zinner and Encke respectively. Statistical testing established the reality of these groupings at a high confidence level. They have short dynamical lifetimes and may represent an intermediate stage in the fragmentation of very large comets; asteroids within these groups may in fact be dormant comets with lifetimes $\gtrsim 10^5$ yr

LLANO DEL HATO ASTEROID SURVEY. PRELIMINARY RESULTS. O. A. Naranjo[1,2] and J. Stock[3], [1]Apartado 690, Mérida 5101A, Venezuela, [2]Facultad de Ciencias, Departamento de Física, Universidad de los Andes, [3]Centro de Investigaciones de Astronomía F. J. Duarte (CIDA), Mérida, Venezuela.

We have begun an asteroid survey using a 1-m Schmidt camera at Llano del Hato National Observatory (Mérida-Venezuela). The survey is been conducted on the plane of the ecliptic. To find asteroids we used a blink comparator, to obtaining positions a PSK-2 in its modality of 5 and 1 µm. Mainly we have used IIa-O plates.

The maximun number of objects found on one plate, of one hour of exposition with sidereal guiding, has been 28 asteroids. The data allow us to estimate a distribution of velocities of objects up to 19–20 magnitudes. The positions has been reported to the MPC. In this work we show preliminary results and a comparation with other surveys done before.

LUMINISCENCE OF ORGANIC MOLECULES IN THE HALLEY COMET

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It has been previously observed (December 1985, G. K. Nazarchuk) that there are two broad features with the centers at 3950 A° (-10,+40 A°) and 5100 A° (±50 A°) in the continuum of the Halley comet. They are parts of the scattered solar continuum. The feature at 5100 A° has been observed as far as 2000 km from the nucleus. The feature at 3950 A° was more longlived and has been observed at the nucleocentric distances up to 20000 km.

Assumption is making that there are the luminiscence features of unknown origin. The luminiscent spectra of some alternative sources in the optical region are qualitatively analyzing: (a) the sputtering of water ice crystalls at temperature below 100 K by electrons with the energy between 20 and 300 eV; (b) continuous spectrum of C_2H radical which arises under photolysis of the C_2H_2 molecules; (c) the photoluminiscence of lonsdaleite crystalls which are the white grains of diamond and may be included in composition of graphite particles; (d) the photoluminiscence of the polycyclic aromatic hydrocarbons (PAHs).

The analysis shows that the possible contribution of (b) and (c) sources is sufficiently slight. Further, process (a) may contribute to the detail at 3950 A° if there are the regions in a cometary atmosphere in which the temperature of the ice crystalls is in the range from about 77 K to 100 K. The photoluminiscence of the small PAHs, in environment where these PAHs are slightly pushed by H_2O and OH molecules, is the most probable.

The candidates amongst PAHs are: anthracene ($C_{14}H_{10}$), pyrene ($C_{16}H_{10}$), chrysene ($C_{18}H_{10}$), anthrol ($C_{14}H_9OH$) and other small PAHs with adjacent O, OH or H_2O, and, probably, ionized anthracene.

ANOMALOUS DISTRIBUTION OF THE DENSITY OF MOLECULES NEAR THE NUCLEUS OF COMET HALLEY. H. K. Nazarchuk, Main Astronomical Observatory of the Ukrainian Academy of Sciences, Kyiv, 252127, Ukraine.

The distribution of the surface brightness in the inner coma of Comet Halley has been obtained. The series of the spectra that had been observed by TV-scanner of the 6-m telescope was used for this purpose. On November 15, 1985, Comet Halley occulted a star. One of two input diaphragms of the spectrograph was pointed onto the occulted star while another traced the inner coma. There were 7 spectra in different points of coma within 135 arcsec. The nearest point of the tracing was at 12 arcsec (6450 km) from the nucleus. The Sun-comet-Earth angle was about 5°.

The intensities of the continuum (at 4132A, 4387A, and 4594A) and molecular bands of CN (4214.7A), C3 (4019.4 and 4051.6A), and C2 (4713.2 and 4734.9A) were measured in the same relative units. The result are given in the table below.

	Mean Projected Nucleocentric Distance			Intensity				
			Continuum	CN	C3		C2	
#	arcsec	km	(averaged)	4215	4020	4050	4714	4735
1	67	36000	0.045	0.119	0.136	0.225	0.194	0.126
2	36	19500	0.050	0.125	0.174	0.293	0.234	0.190
3	19	10200	0.033	0.113	0.185	0.216	0.241	0.153
4	33	18000	0.025	0.113	0.110	0.157	0.141	0.142
5	63	35000	0.013	0.071	0.092	0.110	0.098	0.089
6	92	49500	0.013	0.064	0.050	0.056	0.126	0.115
7	122	65500	0.012	0.064	0.052	0.077	0.081	0.086

Points #1 and #2 are on the Sunward side of the coma; the other points are situated on the opposite side. One can see an interesting anomaly in the space distribution of the monochrome brightnesses. In the narrow range of nucleocentric distances the intensities of C2 and C3 have inverse dependence on the nucleocentric distance. This inversion (the minima at 90 arcsec for C3 and at 60 arcsec for C2) is real and can not be interpreted as an instrumental distortion or error. The continuum as well as the emission of CN does not show this anomaly clearly. There may be only suspicion that it is present too.

The phenomenon looks like the action of an unknown weak additional source of C2 and C3 molecules at 30000 and 70000 km correspondingly. Can the CHON-particles be this source? Why not?

Getting frozen of the molecules on dust particles in contracting protosolar nebula

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It appears, the molecules containing some heavy chemical elements (except hydrogen and helium) already got frozen on dust particles and condensed in period of free-fall protosolar nebula collapse, i.e. these processes were effective long ago period, when the nebula collapsed to its dimension comparable with one of present planetary system (≈ 50 AU). So, a creation of cometary material already began at large distances (as far as some thousands AU) from protosolar nebula center.

Applicability of meteor radiant determination methods depending on the type of orbit
II. Low-eccentric orbits

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All known parent bodies of meteor showers belong to the group of bodies moving in high eccentric orbits ($e \geq 0.5$). Recently, the asteroids in low eccentric orbits ($e < 0.5$) approaching to the Earth's orbit were suggested as another population of possible parent bodies. The present paper deals with the problem of calculation of theoretical meteor radiants connected with the bodies in low eccentric orbits from the point of view of optimal results depending on the method used. The paper is a continuation of our previous analysis of high eccentric orbits published in Contrib. Astron. Obs. Skalnaté Pleso. The analysis covers Porter's, Steel-Baggaley's and Hasegawa's methods together with some additional methods resulting from mathematical modelling.

In order to be able to compare suitability of application of the individual radiant determination methods, it is necessary to determine the accuracy with which they approximate real meteor orbits. To verify the fitness of the original orbit of the parent body with that of the meteoroid having one node at 1 AU, Southworth-Hawkins D-criterion was applied (Southworth and Hawkins, 1963). $D \leq 0.1$ means good fitness of the orbits, $0.1 < D \leq 0.2$ is considered for probable fitness of the orbits and $D > 0.2$ the probability of fitness is rather low and the change of the orbit unreal.

The optimal methods referring to the smallest values of D for given types of orbits are shown in two series of six plots. The largest application in the population of low eccentric orbits has an adjustment of the orbit by variation of both the perihelion distance and eccentricity considering a minimal change.

A few applications are shown.

Numerical Simulation of Impacts on Small Asteroids: Application to 951 Gaspra.

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A numerical hydrodynamic model of a projectile impacting a body, which includes fracture (Asphaug et al. 1992, *LPSC* XXIII:45), allows exploration of the mechanics of impacts into asteroids. We have considered a spherical target with the volume of 951 Gaspra ($r = 6400\,\mathrm{m}$) consisting either of solid basalt or of fragmented basalt. In the solid basalt case, assuming a relative velocity of 5300 m/s, an impact deposits regolith over the entire surface, in events large enough to produce craters 1 km or more in diameter. Any existing surface regolith jumps ~100 m due to the "jolt" of the impact, which tends to obliterate small craters, while preserving inhomogeneities in surface composition. The results indicate that impacts that create larger craters also globally increase the regolith thickness.

The largest impact modeled (284 m radius projectile) showed marginal catastrophic disruption of the target: 20% of the target was accelerated to escape velocity. A basin was formed nearly as big as the asteroid. The interior of the body was significantly fractured: the largest remaining piece in the interior rubble had a size of 1000 m. Thus this impact rubblized the approximately 80% of the portion of the body which did not escape.

Examination of the results of the model suggests that the physical processes are in the gravity-scaling regime (Housen et al. 1983, *JGR* 88:2485), rather than the strength regime usually assumed for small targets, due to substantial, shock-induced fragmentation of the rock before ejecta flow begins. This results in the low ejecta velocities, which allow regolith deposition.

The steep size-frequency distribution of craters observed on Gaspra requires a steep impactor size-frequency distribution. In addition, crater erasure due to "jolting", combined with "cookie-cutter" erasure should cause noticeable flattening of such a steep distribution ("saturation") in approximately 75 My. The observed steep size distribution of craters requires either an impactor size distribution steeper than an incremental distribution $dN(d) \propto d^{-4}$, or a 500-million-year impact to have occurred approximately 50 My ago. The latter seems most plausible. This analysis predicts that such an event is likely on on 10% of Gaspra-size bodies. Asteroid 243 Ida (soon to be imaged by Galileo) and other asteroids to be imaged in the future will improve the statistics; most should have a flatter crater size-frequency distribution.

IMAGING OF ASTEROID 4179 TOUTATIS WITH THE HUBBLE SPACE TELESCOPE

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and

David Tholen

University of Hawaii

On 10 December 1992 we obtained four images of asteroid 4179 Toutatis when it was 0.0291 AU from Earth and at 90 degrees solar phase angle using the Planetary Camera on the Hubble Space Telescope. The images we obtained show evidence of possible marginal resolution after deconvolution with both stellar and theoretical point-spread functions, although the data are also consistent with an unresolved source. We conclude that the maximum illuminated dimension at the time of our observations was less than 2.6 km for a higly irregular object. A near-spherical body would have a diameter of less than or equal to 1.9 km. These results are at odds with ground-based observations of the lightcurve which were near a local maximum at the time of our observations and with radar reflection data that indicate two lobes with diameters as much as a factor of two greater than our upper limit.

The 10μm feature of aggregates in comets

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We have examined the thermal emission from the cometary dust aggregates with fractal structure, consisting of multi-components. The aggregates are modeled by (i) 2 components-fractal particles with randomly mixing of olivine and magnetite, (ii) 2 components-fractal particles with core-mantle structure (the core is magnetite and the mantle is olivine), and (iii) 2 components-compact sphere. By using DDA (Discrete Dipole Approximation) and Mie theory with Maxwell-Garnett theory, numerical simulations of thermal flux from the cometary grains with the mass distribution detected in comet P/Halley (Mazets et al. 1986) have been performed for various values of fractal dimension D and a mixing mass ratio R of olivine to magnetite. It is found that the 10μm feature mainly depends on D, whereas the temperature of aggregate strongly depends on R. Types (i) and (ii) generally have the similar emission features, although type (ii) tends to show slightly higher temperature than type (i). Our results have also revealed that, when $D \sim 2$ and $R \sim 1$, this aggregate shows the remarkable twin-peaked structure in the 10 μm silicate band, which fitts well to that observed, e.g. in comet P/Halley, and furthermore gives a reasonable temperature close to that observed in P/Halley, e.g. 385K at a solar distance of 0.79AU.

We have also investigated the far-infrared spectrum of these aggregates and compared it with observations.

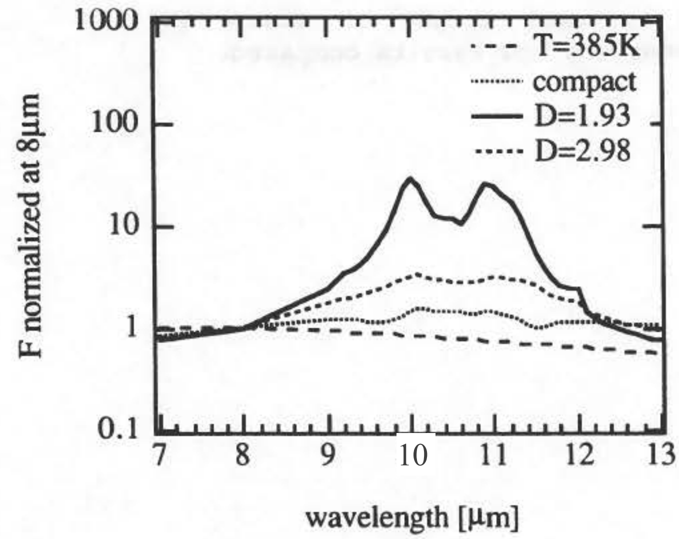

Fig.1 Thermal flux normalized at a wavelength of 8μm from the aggregates with a fractal dimension D consisting of olivine and magnetite. A mass ratio of olivine to magnetite is unity. The mass distribution of the aggregates is applied from that deduced from the dust measurements in comet P/Halley by Mazets et al. (1986)

AUTOMATIC MEASUREMENT OF IMAGES IN ASTROMETRIC PLATES

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We present our results on the process of automatic detection and measurement of objects in astrometric plates. To this purpose, we have studied, compared and developed classical and new algorithms to better determine the parameters of the images we are working with.

The main subjects of this work are:

The comparison of methods for star image enhancement.

The use of algorithms for removing anomalous images and noise.

The determination of objects shape and the discrimination between different kind of images.

Application of models to determine star positions with high accuracy.

These methods are applied to real images of stars and asteroids on astrometric plates and the results compared.

Near Opposition Phase Effects in the Dust Coma of Comet Austin ($1989c_1$) and other Comets.

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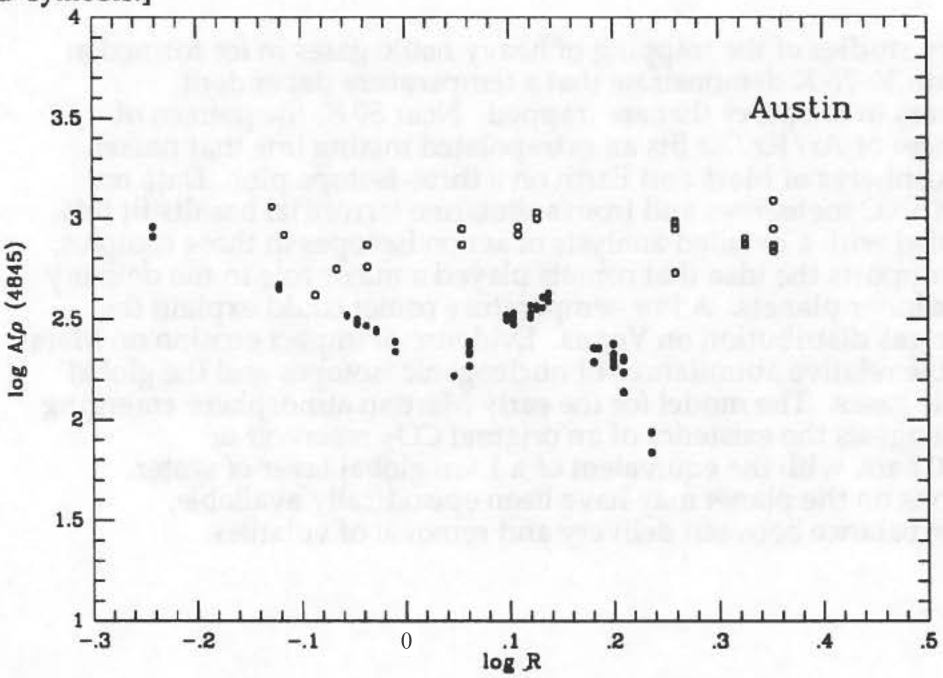
Asteroids, the Moon, and other atmosphereless solar system bodies are known to exhibit phase effects including a brightness surge when observed near opposition, due presumably to preferential backscattering and/or reduced shadowing. An opposition surge or other phase effects in the continuum of an active comet can serve as a diagnostic of the physical properties of the scattering particles in the coma. We are currently investigating phase effects as the explanation for the peculiar post-perihelion behaviour of the continuum of Comet Austin ($1989c_1$).

[The figure below plots log Afρ, a measure of the dust production vs. log R, heliocentric distance, with pre-perihelion observations as open symbols and post-perihelion observations as solid symbols.]



While the post-perihelion dust production originally diminished in a similar fashion to the volatile production rates, a pronounced surge in the Afρ value is quite evident beginning at 1.15 AU (0.06 in log R). This sharp increase in activity coincides with a two week span of observations in which the phase angle changed rapidly from 60° to 3°. This increased production was not observed in any of the emission species, confirming that it is an observational effect of the changing phase angle on the scattering grains.

The scattering function for the cometary grains is currently being quantitatively determined for Comet Austin. Furthermore, we are investigating similar phase effects in the dust coma of Comet P/Halley during the near opposition observations of Nov. 1985 and in other comets from our photometry database.

EARLY BOMBARDMENT BY ICY AND ROCKY PLANETESIMALS: CONTRIBUTIONS TO THE ORIGIN AND EVOLUTION OF INNER PLANET ATMOSPHERES

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Laboratory studies of the trapping of heavy noble gases in ice formed at temperatures from 30-75 K demonstrate that a temperature dependent fractionation occurs in the gases that are trapped. Near 50 K, the pattern of relative abundances of Ar/Kr/Xe fits an extrapolated mixing line that passes through the atmospheres of Mars and Earth on a three-isotope plot. Data on noble gases from SNC meteorites and from submarine terrestrial basalts fit this same line. Coupled with a detailed analysis of xenon isotopes in these samples, this correlation supports the idea that comets played a major role in the delivery of volatiles to the inner planets. A low-temperature comet could explain the anomalous noble gas distribution on Venus. Evidence of impact erosion on Mars can be found in the relative abundances of nucleogenic isotopes and the global depletion of noble gases. The model for the early Martian atmosphere emerging from this work suggests the existence of an original CO_2 reservoir of approximately 10 bars, with the equivalent of a 1 km global layer of water. Clement conditions on the planet may have been episodically available, depending on the balance between delivery and removal of volatiles.

Comets and meteorites

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By testing fireballs, associated with cometary fragments, in the Earth's atmosphere, their depth of penetration, and by comparing their theoretical residual masses with meteorite falls, it is argued that there are also chondrites, besides volatiles, in cometary nuclei.

Ordinary chondrites mostly orbit in Apollo- Amor- and Athenae-type orbits, and carbonaceous chondrites probably predominate in more eccentric orbits whose aphelia are beyond Jupiter. Chondrites probably originate in bodies larger than comets are today. The history of the relations between the parental bodies of chondrites and comets should be studied in greater detail.

A SEMIEMPIRICAL MODEL OF CATASTROPHIC DISRUPTIONS: RECENT IMPROVEMENTS

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Several improvements to the semiempirical approach to the physics of catastrophic breakup events (see Paolicchi et al.,1989,Icarus 77,187) have been recently carried out and are described in the present paper. The main features of the model which have been significantly changed are concerned with the problem of the derivation of a set of realistic, non overlapping fragments, as well as with a better treatment of the role played by gravitational effects, when sizeable parent bodies are shattered by catastrophic collisions.
The main physical results obtained by means of the improved model are discussed, and compared with the evidences coming from laboratory experiments and astronomical observations. Some problems related to the possibility of deriving reliable mass distributions of the fragments are pointed out and extensively discussed.

Trojan Precursors in the Primordial Solar Nebula

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If a $13M_{\oplus}$ Jupiter core is assumed not to disturb the mass distribution in the solar nebula, the dissipation of orbital energy of planetesimals librating about the L4 (leading) and L5 (trailing) Trojan points due to nebular drag does not generally result in rapid growth in the libration amplitude and loss from the region. Dissipation of orbital energy while the planetesimal is further from the Sun than the stationary point in the frame rotating with Jupiter (or the elliptic fixed point in a surface of section if Jupiter's orbit is eccentric) causes the amplitude of libration to be reduced, whereas dissipation while it is closer to the Sun than this point increases the amplitude of libration. The effects of dissipation outside the stationary point nearly cancel the effects of the dissipation inside, resulting in either a very slow increase or decrease in the amplitude of libration depending on the details of the nebular model. Those models of the nebula that have a larger ratio of the midplane gas density a small distance outside of Jupiter's orbital distance to the gas density an equal distance inside Jupiter's distance give the librating planetesimals a higher stability. By higher stability we mean that the planetesimal will more likely remain permanently in the region with decreasing amplitude of libration, or if the amplitude is increasing, the rate of increase is lower. The L4 stationary points of Trojan precursors experiencing nebular drag are located more than 60° in front of Jupiter, whereas the L5 stationary points are located less than 60° behind Jupiter. The separation of these stationary points from ±60° increases as the particle diameter d decreases, reaching at the L5 equivalent a maximum of about 108° in front of Jupiter for $d \approx 30\,\mathrm{m}$ (Smaller planetesimals do not librate in front of Jupiter.), but only a few degrees behind Jupiter for $d \approx 1\,\mathrm{m}$. If Jupiter has a non zero orbital eccentricity, the stability of the trailing, L5 planetesimals is increased, but the stability of the leading, L4 planetesimals is decreased. Even if libration amplitudes are increasing slowly, the planetesimals librate around their particular stationary points in the frame rotating with Jupiter for times which are significant fractions of the nebular lifetime. This means that as Jupiter's core grows, it will induce the growth of larger Trojans as planetesimals are concentrated in the librating regions by collisional scattering.

When Jupiter's mass approaches its current value, an annular gap in the distribution of nebular material is believed to form. The reversal of the radial pressure gradient on the outside of the gap means that the planetesimals are accelerated from behind when on the outside of their libration trajectories. This reverses the trend toward smaller libration amplitudes on this part of the trajectory and the libration amplitude is increased on all parts of the libration trajectory. Small planetesimals are quickly lost, although for $d > 3$ km lifetimes are probably longer than the remaining life of the nebula. The inference is that much of the material trapped into libration when Jupiter was small, accumulated to very large bodies before Jupiter got large enough to create a gap. The larger Trojans would survive the dispersing effects of the gap.

The striking asymmetry in the response of the planetesimals to the nebular drag between the L4 and L5 points implies that there should be an asymmetry in the numbers or total mass of Trojans remaining trapped near each stability point after the nebula is dissipated. However, these results favor more material being trapped at the trailing Trojan point, which is apparently contrary to observation. Still, the collisional evolution of the Trojans over 4.6×10^9 years may have skewed the mass distributions in such a way as to mask what was there initially.

ORIGIN OF LARGEST ASTEROIDS' ROTATION

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The evolution of asteroids can be divided into three stages. In the first stage, the growth of planetesimals takes place in the region between Jupiter and Mars. During the second stage, the massive preplanetary bodies penetrate into asteroids' zone from the region of Jupiter. As a consequence the removal of a major part of the matter from the asteroids' zone keeps pace with the increase of relative velocities of bodies, and the accumulation process stops. The third stage is the one of the postaccumulation collisional evolution of asteroids.

Is there any evidance of the first stage of evolution - of their growth? In our earlier works [1, 2] we suggested a theory of the acquisition of angular momentum by growing planets and evaluated the probabilities of the prograde rotation at a given distance from the sun P_+. This theory can be applied to minor planets too. The comparison of theoretical estimates of the angular momentum of the largest asteroids acquired during their growth and of the observational data on rotation parameters of asteroids has shown that the rotation of the largest of them should be a primordial one. It is obtained in the accumulation process, and the consequent collisional evolution did not contribute any essential changes to its value. Moreover, from the comparison of P_+ for the largest asteroids and the observed distribution of obliquities of their spin axes (with respect to their orbital planes) it follows that at the second stage of the evolution of asteroids the processes of catastrophic disruption and of the removal of the matter from the asteroidal zone prevailed. The largest asteroids which avoided the catastrophic collisions with bodies from jupiter's zone, continued to grow, and the surface density of matter in their feeding zones effectively decreased primarily due to the loss of larger bodies. The increase of the relative velocities of the remaining asteroidal bodies had taken place when the major part of the matter from the asteroidal zone was already lost.

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ON THE DETERMINATION OF METEOROID ORBITAL ELEMENTS

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The classical method of determination of orbital elements of meteoroids is based on a sequence of corrections applied to velocity vector of observed meteoroid. The main purpose of such approach consists in the determination of meteoroid motion under the gravitational influence of the Sun while we are able to observe this motion under the influence of the Earth. The classical method treats this switch from Earth's gravitational center to the solar one as jump-like process assuming tacitly the size of the activity sphere of Earth is negligible as compared with the size of this sphere of the Sun. Using other words, the time the meteoroid needs to pass the Earth's activity sphere is considered to be negligible in comparison with its orbital period. Assuming on the contrary to classics the time of the passage is finite we should treat the meteoroid motion as continuous with respect to its the time evolution from the time moment of its apparition to the moment the Sun's gravitational influnce surely dominates. As a consequence, we have numericaly integrated the equations of motion of meteoroid under the simultaneous action both of the Sun and the Earth from the time of the appearance of particular body back to the moment the meteoroid - Earth distance reached at least 10 millions km to ensure the body was well inside the sphere of activity of the Sun. In order to visualize the differences we have used precise data of 17 fireballs photographed by European fireball network in the past. It is shown that the orbital elements following from the new method differ in general from classical those. We can draw the general conclusion that the slower the meteoroid the lesser its eccentricity as well as semi-major axis as compared with their classical values.

BACKSCATTERING OF LIGHT BY SNOW: LABORATORY EXPERIMENTS

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We present photometric measurements of snowball fields carried out by one of us in cold, dry outdoor conditions in the winters of 1979 and 1980 at Aarne Karjalainen Observatory, Kiiminki, Finland. The snowballs consisted of varying proportions of pure snow (typical particle size 100 μm) and extremely black, fine–grained boron carbide (B_4C, particle size 10 to 50 μm). The geometric albedos ranged from 5% for the darkest to 44% for the pure snow samples. The smallest phase angle was 0.3 deg, and the measurements were carried out in white, unpolarized light using a photometer designed for asteroid observations.

Almost all the measured phase curves show the kind of sharp opposition effect observed in Saturn's rings, many planetary satellites, and the asteroids (44) Nysa and (64) Angelina. The opposition effect sets in at phase angles between 1 and 2 deg and, depending on the purity of the snowballs, amounts to as much as a 0.3 mag brightening at a phase angle of 0.3 deg. It is intriguing that the measured opposition effect is enhanced with an increased proportion of boron carbide; that is, in darker samples.

Can the measurements be explained by the coherent multiple backscattering mechanism? For pure snow with large particle sizes, the typical free paths for multiply scattered light can be large compared to the wavelength, and can theoretically result in an extremely narrow, unobservable opposition effect. When boron carbide is added, the free path becomes shorter, which can broaden the opposition effect to observable widths. However, shadow–hiding due to the dark boron carbide particles may also affect the opposition effect.

A Search for Fireball Streams among Photographic Meteors

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Terentjeva (1990) in her analysis of 554 fireballs has reported to discern 78 fireball streams. The present paper summarizes a similar analysis of a set of over one thousand photographic orbits of meteors brighter than the magnitude -3. Fireball streams are searched by a computerized stream-search procedure based on Southworth-Hawkins D discriminant, considering radiants, their daily motion, sizes and shapes of the radiant areas. Except of the fireballs belonging to the known meteor streams, substantially lower number of possible fireball streams was found. The mean orbits, radiants and periods of activity of the streams are presented.

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FROM THERMODYNAMICS AND ALGEBRA TO METEOROID STRUCTURE.

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The interaction of meteoroids with a planetary atmosphere formulated previously by the author (Rajchl 1979) — using the production of entropy, i.e the ratio of the familiar ablation and dynamics equations of meteor physics — led to a cross–complementarity relation between bright and faint meteors, confirmed also observationally (Rajchl 1987). This non–equilibrium thermodynamical formulation enables its further, non–linear extention via an earlier, interaction layer concept (Rajchl 1969). All such results, in combination with a cubic–equation– bifurcation solution, following from algebra and composed of the sum of the ablation and dynamics equations, compared with some observational consequencies, forces to the following conclusion: a distinction between compact and fractal meteoroid material structure is more fundamental in respect to the normal and anomal behaviour of both, the faint and bright meteors, than composition connected with cometary and carbonaceous nature of bodies. New hypothesis about the various structures origin in relation to different meteor velocity groups is offered.

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Long-Slit Spectral Imaging of Comets Austin and P/Brorsen-Metcalf

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David G. Schleicher (Lowell Observatory)

In this study we present long-slit CCD spectrophotometry of comets P/Brorsen-Metcalf (1989 X) and Austin (1990 V). The analysis presented here is a continuation of work previously presented in which we determined Haser scalelengths for CN, C_2, C_3 and CH (*BAAS* **24**, p.1002, 1992). The motivation for this project derives from attempts to understand and define the comparative compositions of comets. In particular, it is necessary that one precisely determine the scalelength of a species in order to determine its production rate, and thus relative abundance, from measurements such as aperture photometry. Here we will present long-slit CCD spectra acquired over wavelengths ranging from about 3300 to 10,000 Å. Some of the new data presented here were acquired with the slit offset from the nucleus, which, when combined with the nuclear-centered spectra, yield a much larger spatial extent than otherwise possible. We will also discuss the effects of solar variability on scalelength determinations, as these can constitute a significant complication, especially relevant in understanding and modelling spatial profiles.

The Thermal Emission Spectrum of Airless Bodies in the Solar System

Russell O. Redman

A model will be provided for the complete thermal electromagnetic spectrum of an airless body from IR to radio wavelengths. Particular attention will be paid to the effects of the dielectric properties and the size distribution of grains in the regolith. The model allows us to see which regions of the spectrum are most sensitive to particular physical effects.

Polarization profiles of the Grigg-Skjellerup coma from OPE/Giotto

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Optical polarization probing of the coma of comet Grigg-Skjellerup has been performed by the OPE experiment on board the Giotto spacecraft. Because of the geometry of the encounter, scans of the inner coma were obtained at a phase angle of about 90°. Polarization profiles, with a resolution up to 56 km, and a distance to the nucleus smaller than 10000 km (dark and sunny sides), are presented for two dust continuum channels and for the C_2 gaseous channel.

Significant spatial variations of the polarization of scattered solar light are detected and compared with the corresponding brightness evolution (Levasseur-Regourd et al., Planet. Space Sci., 1993). Three different domains are pointed out: two regions of low polarization (about 10 percent) correlated with maxima of brightness, a region of high polarization (about 25 percent) associated with a jet from the nucleus, and an outer coma region (about 20 percent; distance to the nucleus in the 2000-10000 km range) with no significant variation. The evolution in the physical properties of the grains demonstrated by these results will be discussed.

Sources of the 3.4 μm Feature in Comets.

Dennis C. Reuter, Michael J. Mumma (NASA/GSFC), Susan Hoban(USRA)

Infrared spectra of recent comets have shown excess emission in a relatively narrow feature centered about 3.36 μm, the so-called "cometary organic feature", which has been ascribed to molecular C-H stretching modes. Recently, methanol (CH_3OH) has been detected in several comets in both IR (1-3) and millimeter wave (4,5) observations. Methanol production rates have been determined from the 3.52 μm ν_3 band flux in the infrared and from individual line intensities in the millimeter wave region. For those comets observed in both spectral regions, the production rates obtained from the two techniques agree to within their respective uncertainties. If, as seems probable, the 3.52 μm feature is due to ν_3 in CH_3OH, then part of the 3.4 μm feature must be due to the ν_2 and ν_9 bands of this species. Using a model developed for the cometary emission spectrum of CH_3OH (6) the ν_2 and ν_9 cometary flux may be estimated by scaling the model by the same factor required to match the observed ν_3 flux. This process is illustrated in the below, where the data are from recent observations of comet P/Swift-Tuttle on 1992 November 8 (obtained with the CRyogenic SPectrometer at the Kitt Peak National Observatory, $\lambda/\Delta\lambda = 88$), and the solid line is the methanol model. The residual spectrum, obtained by subtracting the model from the data and shown in the bottom frame, must then be due to something other than the ground state of CH_3OH. The appearance of this residual varies somewhat among the six comets for which IR data are available, and methanol contributes between 25% and 60% to the 3.4 μm flux. The heliocentric variation and possible progenitors of this residual emission will be discussed.

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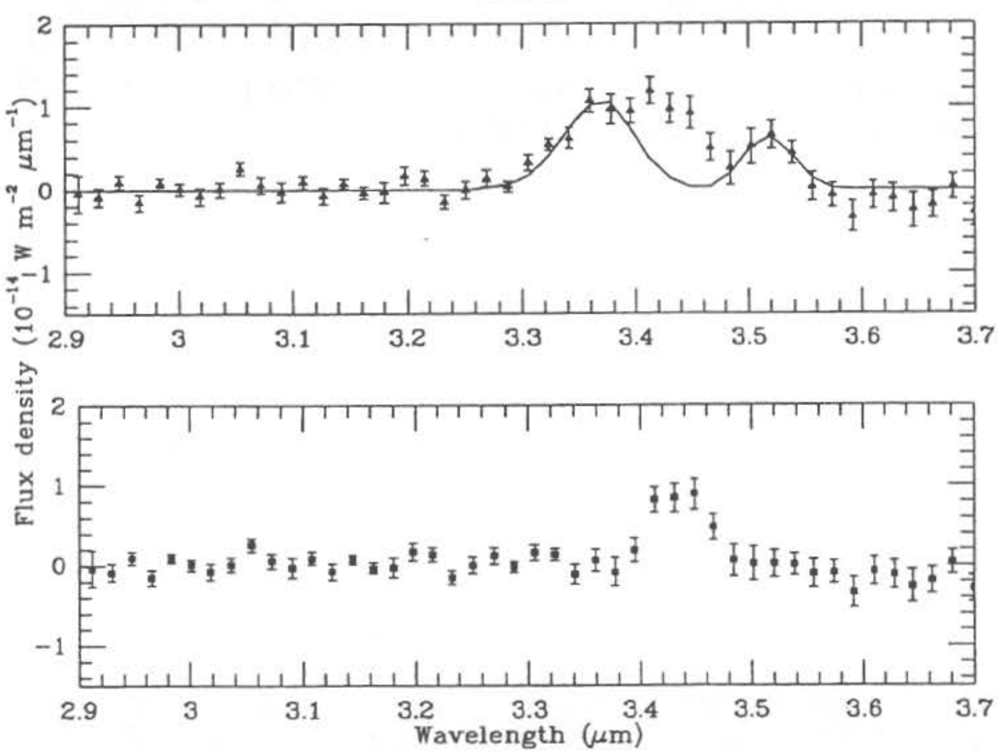

Analysis of Identified Iron Meteoroids: Relationships with M Type Earth-Crossing Asteroids

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Using the approach of ReVelle and Rajan(1988; 1989) and a new technique developed by Ceplecha(1991; 1992), we have re-analyzed fireballs from the U.S. Prairie Network data whose behavior was similar to that expected of relatively large Nickel-Iron meteoroids entering the atmosphere. ReVelle and Rajan originally examined the fireball data and found six objects that satisfied criteria similar to those developed by Wetherill and ReVelle(1981) for locating chondritic meteoroids among the fireballs. The criteria used included a near-matching of the theoretical and the corrected, observed end heights and a photometric to dynamic mass ratio near unity. In this work we have re-examined these six cases using a fragmentation analysis technique developed by Ceplecha. The analysis uses the observed distances flown by the body along its trajectory and fits them to theoretical values expressed as a function of time. The resulting values contain also the place and degree of fragmentation which the individual bodies experienced during entry. As a part of this process the mean ablation coefficient is also determined. After re-analysis of these six cases, we can say with confidence that five of the six bodies identified had no fragmentation at all and that four of the six also had exceptionally large ablation coefficients, a feature that is characteristic of such bodies according to ReVelle and Rajan. In this paper we will present a detailed analysis of these meteoroids both from a dynamics approach and from an orbital viewpoint. Thus, we hope to be able to link these fireballs more substantially to bodies that have already been shown to be M class, earth-crossing asteroids(Tedesco and Gradie, 1987). The identified objects and some of their preliminary physical properties are as follows:

PN Number	Station	Ablation coefficient (sec^2 / km^2)	% Fragmentation
39158	2W	0.051 +/- 0.004	0
	6E	0.031 +/- 0.003	0
39773	7W + 16N	0.070 +/- 0.002	0
39784B	2N	0.060 +/- 0.080	0
	10E	No solution	-
39938B	17E	0.002 +/- 0.003	0
	7W	0.010 +/- 0.006	0
41757	8N	0.148 +/- 0.003	0
	15N	0.119 +/- 0.010	0
42550	10S	0.175 +/- 0.004	99.9 +/- 0.1
	6N	0.110 +/- 0.005	99.8 +/- 0.2

Lightcurves and rotational periods of main belt asteroids.II

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Within the collaborative program between the Istituto di Astronomia dell'Universita' di Catania and the Osservatorio Astronomico di Torino, aiming to enlarge the data set of the rotational properties of minor planets, the photoelectric observations of 8 asteroids are presented.
The B and V lightcurves of 11 Parthenope, 121 Hermione, 136 Austria, 153 Hilda, 352 Gisela, 419 Aurelia, 665 Sabine and 914 Palisana are shown and the results obtained from their analysis are discussed.

ORIGIN OF ASTEROIDS AND A COMETARY CLOUD

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The asteroid belt and the cometary cloud are by-products of the process of formation of the planets and their origin is tightly connected with the latter. At the present time we have a more or less satisfactory theory of a final stage of accumulation of bodies (orderly growth of the largest planet embryos with the time scale of 10^8 yr in the terrestrial region) as well as numerical simulations of an early stage of this process (rapid runaway growth of larger planetesimals into planet embryos with the time scale of 10^5 yr). An intermediate stage has not yet been studied quantitatively. At this stage relative velocities (eccentricities) of bodies increased much faster than before and planetesimals of the Jupiter's zone began to penetrate the asteroid zone and somewhat later the transplutonian region. Several mechanisms took part in preventing formation of a normal-sized planet in the asteroidal zone (AZ) and in removing most of bodies from the zone: a) Sweeping of AZ bodies by more massive Jupiter zone bodies (JZB) penetrating AZ due to their larger orbital eccentricities. b) Increase of random velocities by mean-motion and secular resonances. Resonant perturbations of AZB could be effective when the resonances scanned through the asteroid belt due to variation of Jupiter's distance from the sun while it accreted the gas and ejected bodies from the solar system. c) Smaller bodies up to a few km could be removed from the AZ by gas drag in the radial direction toward the higher gas pressure. Relative role of these mechanisms is not quite clear.

Hypotheses of origin of the cometary cloud are discussed. The only plausible mechanism of its formation is the growth of planetesimals in the region of giant planets, increase of semimajor axes of their orbits by the perturbations of these planets to high values $a > 5000$ AU and then decoupling of the perihelia from orbits of outer planets by tidal forces of the Galaxy and stellar perturbations. Continuous dissipation of comets from the outer Oort cloud implies its replenishment by comets diffusing from an invisible more dense inner cometary cloud.

CO in Comet Halley

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The fact that CO is the second most abundant species observed in cometary comae together with the low sublimation temperature of CO suggest that CO may be the source behind cometary activity at large heliocentric distances. Thus, CO is a very important tracer in understanding the chemistry and activity of cometary nuclei.

An analysis of the CO distribution of the coma of Comet Halley along the path of the Giotto spacecraft by Eberhardt *et al.* (1987, *Astron. Astrophys.* **187**, 481-484) concluded that a distributed source is responsible for >50% of the CO in the coma. However, they do not discuss the three-dimensional nature of the source. On the other hand, a recent analysis of CN jets of Comet Halley by Klavetter and A'Hearn (1993, Submitted to *Icarus*) indicates that >10-55% of CN in the coma is due to jets and are produced outside the nucleus.

We have modelled the CO distribution due to gaseous jets and compared them to the one observed by Giotto. We will discuss the results of modelling for the jets formed by active areas in the rotational model of Belton *et al.* (1991, *Icarus* **93**, 183-193). We find that the active area number 1 in that model may be responsible for a significant fraction of the observed CO distribution. The relevant physical parameters for the jets as constrained by the observations and comparisons with other studies will also be discussed.

DOES THE OORT CLOUD EXIST? S. Sandhu and M. Solc, Institute of Astronomy, Charles University, Prague, Czech Republic.

Once accepted, the existence of Oort cloud was never questioned. Nobody except Lyttleton questioned the existence of the Oort cloud. In this paper, the formation and existence of the Oort cloud is reviewed. It is found that there are some serious mistakes in the data of the original orbits of comets. How a comet such as 1941I can have a bound orbit, which has aphelion distance of about 31.6 Ly. Two more comets 1897I and 1952VI also come from interstellar space with elliptical orbits. So the data regarding the original orbits are erroneous and cannot be relied upon. This single point is sufficiently strong to discard the concept of the Oort cloud. According to the formation scenario reviewed in this paper, a spherically symmetrical cloud cannot be formed. Some more problems, like the clustering of perihelia and aphelia of long-period comets toward the general directions of solar apex and solar antapex respectively and the inclination distribution of long-period as well as short-period comets are also addressed. If we discard the concept of the Oort cloud, we must search for a reliable alternative for it. A concept of satellite cloud(s) is proposed to replace the Oort cloud. And it can solve many of the existing problems regarding cometary origin and dynamics, and opens new windows to look upon the expanding horizons of new ideas.

COMET TAXONOMY AND EVOLUTION

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Comets are widely believed to be the most pristine remnants from the epoch of solar system formation and, as such, can provide important clues to the physical and chemical processes which took place at that time. For this reason, much of cometary research is aimed at obtaining an understanding of the origin, basic compositional and physical characteristics, and fate of cometary nuclei.

Numerous papers in recent years have explored the dynamical evolution of cometary orbits and the evidence that there are two reservoirs of comets – the Oort cloud and the Kuiper belt – which are the sources of dynamically new comets and short-period comets, respectively. If this scenario is true, then compositional differences might be expected because the comets in these two groups would have formed at different locations and, thus, under different conditions within the proto–solar nebula. While not wholly immune from evolutionary processes while "stored" in either the Oort Cloud or Kuiper Belt, one would expect that any compositional differences would still be evident today. Thus far, quantitative studies of the chemical composition of comets – based on abundances and production rates of species within cometary comae – do not show clear evidence for this type of trend with orbital dynamics. However, substantial evidence of compositional differences among comets does exist. While the majority of comets studied have the same basic composition, significant depletions or enhancements of certain species have also been observed in many comets. For instance, CO has been reported by Feldman (in *ACM II,* Lagerkvist *et al.*, eds., pp. 263–267, 1986) to vary from 1% to 27% with respect to water. Our own taxonomic studies indicate that about 30% of comets are depleted in C_2 and C_3 (but not CN) by various amounts (up to a factor of 20) (Schleicher *et al.*, *Bull. Amer. Astron. Soc.* **24**, 1004, 1992), while Comet Yanaka (1988r) was observed by Fink (*Science* **257**, 1926–1929, 1992) to apparently have a "normal" abundance of NH_2 with respect to water but with CN and C_2 depleted by factors of 25 and 100, respectively. These and other compositional data sets will be the primary focus of this paper.

The evolution of comets is another important area of study, and a variety of evidence for evolutionary effects also exists. For instance, dynamically new comets are observed to be preferentially brighter prior to perihelion than after, possibly due to the higher volatility of the original surface compared with material deeper within the nucleus. There are well–established cases of short–period comets fading with successive apparitions and eventually disappearing, while other comets have been mis–identified as asteroids due to their asteroidal appearance on some occasions. While the data available for investigating evolution based on chemical composition is much more limited, I will present what evidence there is and discuss our current state of knowledge.

Observations of Parent Molecules in Comet Swift-Tuttle

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We present observations of millimeter and submillimeter wavelength rotational transitions of the cometary parent molecules HCN, H_2CO and CO in Comet Swift-Tuttle. Detections of the HCN J=3-2, HCN J=4-3, H_2CO $5_{15}-4_{14}$, and H_2CO $3_{12}-2_{11}$ transitions were obtained during November 1992 with the Caltech Submillimeter Observatory 10m antenna. A search for the CO J=3-2 transition was also carried out with this instrument and yielded negative results. Finally, a marginal detection of the J=1-0 transition of HCN was made with the Five College Radio Astronomy Observatory 14m antenna during this period. A spectrum of the J=3-2 HCN transition obtained at the CSO on 12 November 1992 is presented below.

Analysis of the data to determine production rates and other physical properties of the comet is somewhat complicated by uncertainties in the ephemerides used to track the comet, since they contained errors comparable to the beam size of the antenna. However, typical values of the HCN production rate appear to be in the range of $2\times10^{26}\mathrm{s}^{-1}$ during the month of November, which would be consistent with a nominal abundance of HCN in the comet. Comparison of observations of the H_2CO $5_{15}-4_{14}$ transition on 16 November with those of the H_2CO $3_{12}-2_{11}$ transition on 25 November suggests a possible increase in the H_2CO production rate from approximately $2\times10^{27}\mathrm{s}^{-1}$ to $4\times10^{27}\mathrm{s}^{-1}$, although we caution that different epherides were used to track the comet on these two dates. The antenna temperature of the H_2CO $3_{12}-2_{11}$ line on 25 November is comparable to that of the HCN 3-2 line on that same day, which is unusual compared to observations of previous comets. The H_2CO line shape at this time is also unusual and has a noticable asymmetry with a strong blueshifted wing.

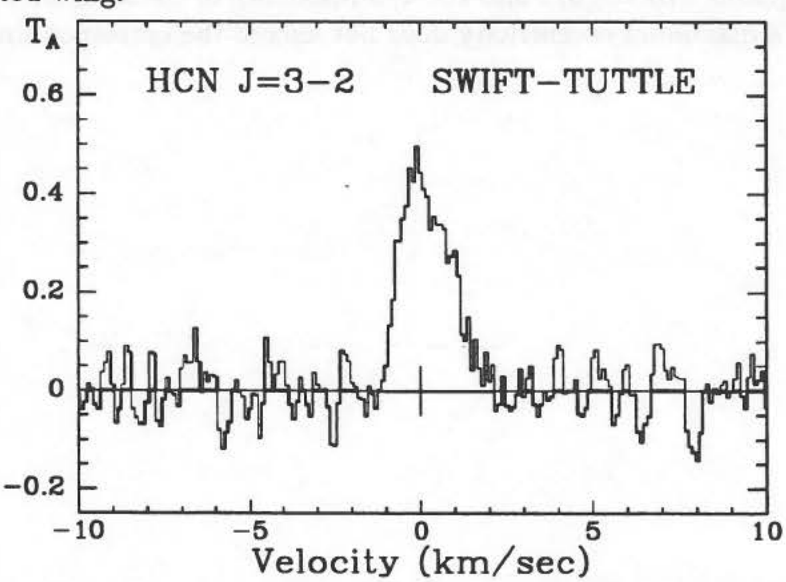

Figure 1: HCN J=3-2 line observed in Comet Swift-Tuttle on 12 Nov. 1992

DIFFERENT MECHANISMS TO DEPLETE THE KIRKWOOD GAPS ?

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Numerical experiments covering some 10 Million years indicate three different mechanisms for the depletion of the Kirkwood gaps, which we like to call the planet-crossing, the secular resonance, and the threshold eccentricity mechanism. It appears that the Kirkwood gaps have not formed in the same way. The results can serve as a basis to explain why resonances are not always associated with depleted regions.

Besides the well known mechanism to deplete the 3/1 resonance region due to Mars- and Earth-crossing (planet-crossing), our new experiments show that approaches to Jupiter can deplete resonance regions without the assistance of Mars or of the Earth. For the latter case, two intrinsic parameters are identified: the amplitude and the frequency of Jupiter's eccentricity. In the latter case, the secular resonance case, gaps can be formed only in a model including all the outer planets.

In the amplitude case, gaps can be formed in the model of the restricted three-body problem with Jupiter on a fixed elliptic orbit. A minimum threshold eccentricity for Jupiter is necessary for gap formation depending on the individual resonance. This explains why the 3/2 and the 4/3 resonance in the asteroid belt is not depleted: Jupiter's maximum eccentricity does not exceed the corresponding threshold eccentricity.

COMET BRADFIELD 1979l: INNER COMA STRUCTURES IN HIGH–RESOLUTION PHOTOGRAPHS

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High resolution photographs of the long-period comet Bradfield (1979l) taken with the ESO 3.6–telescope at La Silla/Chile were used for a structural analysis of its inner coma. The photographs were taken on Jan. 23 and 24, 1980, using red-sensitive as well as blue-sensitive emulsions and broad band filters. They were digitized with a PDS microdensitometer using a step-width of 20μm x 20μm, which resulted in a resolution of about 55 km per pixel.

To search for structures, in particular jets, azimuthal derivatives of the images have been calculated (shift-angle = 5°) with an algorithm described by Larson & Sekanina (1984). The blue-light images, reflecting the gas components for the most part, show a prominent jet originating at the nucleus, while jet-like features are only slightly indicated in the red-light images, representing the cometary dust. During the observations the comet was moving fast across the sky, near the celestrial South Pole, which caused dramatic changes in its position angle. Although this led to a more difficult guiding and allowed only short exposures, it eventually turned out to be an advantage for checking the appliciability of the enhancement technique. While the geometry of the comet on the photographic plates rapidely changed during the observations, the jet in the blue light keeps its position with respect to the star trails. This proves the jet to be a real feature, which was permanently present without major positional changes during the whole observational period of about 19 hours.

Before the discovery of gaseous jets in Comet P/Halley (A'Hearn et al., 1986), jet-like features have commonly been associated with cometary dust. The existence of gas jets was confirmed by several authors (Larson et al., 1987; Cosmovici et al., 1988; Schulz, 1992), but all investigations on the gas and the dust jets found in Comet P/Halley led to the result, that there is no clear correlation between the geometry of the gas jets and dust jets visible in the coma (Larson et al., 1987; Cosmovici et al., 1988). For Comet Bradfield also no relation between gas and dust features could be pointed out, and even the evidence for jets in the red-light images is only vague. The weakness of the enhanced dust features (if actually present) in comparison to the distinct gaseous features may be due to the unusual high emission-to-continuum ratio measured in Comet Bradfield, which was one of the gassiest comets ever observed (A'Hearn et al. 1981). Since gaseous jets can be observed in short-period comets like P/Halley as well as in long-period comets like Bradfield (1979l), their existence in cometary comae seems to be a more ordinary phenomenon than expected. However, they are not necessarily related to the dust particles visible by the refection of the sunlight, which leads to constraints on their formation mechanism.

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2201 Oljato and 1566 Icarus: Comets or Asteroids? A Comparison with Comet Wilson-Harrington also known as Asteroid (4015) 1979 VA

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We report on the results of spectrophotometric observations of the possible cometary candidates 2201 Oljato and 1566 Icarus as well as of the object classified as asteroid (4015) 1979 VA, which was discovered to be in fact Comet P/Wilson-Harrington (1949III) (IAU Circular 5585). Spatially resolved spectra of 2201 Oljato and P/Wilson-Harrington taken with the Ohio State University CCD Spectrograph on the 1.8–m Perkins reflector of the Ohio Wesleyan and Ohio State University at Lowell Observatory on Oct. 7th and 8th, 1992, will be compared. The spectrograph was equipped with a 272 by 528 pixel CCD with a spatial scale of 0.95 arc sec per pixel. The spectra cover the region between 3240 Å and 6160 Å, which includes the significant emission bands of CN, C_2, and C_3. In addition, bias and flat-field frames as well as exposures of a FeNe comparison lamp for wavelength calibration and observations of several spectrophotometric standard stars and solar analogs were obtained to allow the flux calibration and the approximation of the continuum. The images were flux calibrated and upper limits for the production rates of the three radicals in 2201 Oljato and P/Wilson-Harrington were calculated and compared. Additionally, the spectral reflectance of the continuum compared to a solar analog in the region between 3240 Å and 6160 Å will be discussed for both objects.

The ultraviolet spectra of 2201 Oljato (taken on Oct. 14th to 15th ,Oct. 23th to 24th, and Nov. 2nd, 1992), 1566 Icarus (Sept. 30, 1991), and P/Wilson-Harrington (Sept. 30th, Oct. 1st to Oct. 2nd, 1992) observed with the *International Ultraviolet Explorer* (IUE) satellite observatory have also been searched for evidence of gaseous emissions. The upper limits for the production rate of the OH radical determined for all three objects will be compared and discussed. Unfortunately we cannot include an analysis of the continuum in the ultraviolet, because the apparent magnitudes of the objects have only been between 18^m and 17^m and the limiting magnitude for detection of continuum with the IUE is of the order of 10^m.

The comparison of 2201 Oljato and 1566 Icarus with Comet Wilson-Harrington, of which we know that it is at least a dormant comet, shows promise with regard to clues to the question whether 2201 Oljato and 1566 Icarus might be extinct or dormant cometary nuclei. The results will be also discussed in view to necessary future observations.

Comet nuclear magnitudes

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Abstract

Calibration of the sizes of cometary nuclei is dependent on the determination of accurate comet nuclear magnitudes. The measurement of nuclear magnitudes are hindered by the intrinsic activity of comets. When the nucleus would otherwise be most visible, the comet is most active and the nucleus itself contributes only a small fraction of the total light from the comet. Therefore, measurement of comet nuclear magnitudes has generally been limited to when the comet is at relatively large distances. During the course of a systematic program of faint comet astrometric observations using CCD's attached to the Spacewatch Telescope on Kitt Peak, a large and relatively consistent set of measurements of faint, nearly quiescent comets has been obtained. Table 1 contains nuclear absolute magnitudes for some comets for which Roemer (1966) measured photographic nuclear magnitudes. In the table, the observation interval is given; r_{max} and r_{min} is the range in heliocentric distances over which the measurements were made; H_n is the average nuclear absolute magnitude; σ_{H_n} is the standard deviation of the absolute magnitude; $R_{0.02}$ and $R_{0.03}$ are the derived nuclear radii assuming albedoes of 0.02 and 0.03 respectively. The albedo 0.02 is the lower limit used by Roemer, and 0.03 represents the present best estimate of the typical cometary albedo. Once reliable nuclear magnitudes have been determined, the size–frequency distribution of the comet population can be studied (cf. Fernández et al. 1992).

Comet	Obs. interval	r_{max}	r_{min}	H_n	σ_{H_n}	$R_{0.02}$	$R_{0.03}$
P/Encke	1985 – 1986	4.0	3.3	14.1	0.57	7.2	5.9
P/Tempel 2	1986 – 1988	4.3	2.1	14.3	0.68	6.6	5.4
	1992	4.6	4.5	14.5	0.15	6.0	4.9
P/Reinmuth 1	1987 – 1988	3.0	1.9	15.0	0.72	4.7	3.9
P/Grigg-Skjellerup	1987	2.2	1.3	16.2	0.53	2.7	2.2
P/Schaumasse	1992	1.7	1.4	17.2	0.32	1.7	1.4

Table 1: **Nuclear absolute magnitude measurements made with Spacewatch of comets whose sizes were estimated by Roemer.**

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Computer aided Near Earth Object detection – a Spacewatch perspective

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Abstract

The Spacewatch program at the University of Arizona has pioneered automatic methods of detecting Near Earth Objects (NEOs) (Gehrels, 1991). The software presently in use is described by Rabinowitz (1991) and includes three modes of object detection: automatic motion identification; automatic streak identification; and visual streak identification. The present image scale, using a thinned backside–illuminated Tektronix 2048×2048 pixel CCD with 24μ pixels, is 1.076 arcseconds per pixel. For automatic motion detection, with an integration time on the equator of 147 seconds, having the telescope drive off, the 4σ detection threshold is near magnitude V=21.2 for nearly stellar asteroid images. The automatic streak detection is able to locate streaks whose peak signal is above $\sim 4\sigma$ and whose length is longer than about 10 pixels. Some visually detected streaks have had peak signals near $\sim 1\sigma$. Specific examples of each mode of detection will be presented here, along with a discussion of future detailed improvements.

Between 1990 September 25 and 1993 March 4, 36 new Near–Earth asteroids, two comets and a Saturn crossing Centaur, (5145) Pholus, have been discovered with the system. An additional four comets, six NEOs, and (2060) Chiron were also "re–discovered". Each month, $\sim$2,000 main belt asteroids are also detected; their positions are available electronically to whomever wants them. Of the 36 new NEOs, 8 of them were found by visual identification of their long trailed images (Scotti et al., 1991; Rabinowitz, 1993) These include the faintest objects ever detected outside the Earth's atmosphere and the closest observed approaches of any NEO. Additionally, 1991 VG, which was detected automatically, has the lowest relative velocity to the orbit of the Earth and is the third faintest NEO yet detected. The population of the smallest objects detected by Spacewatch is overabundant when compared to an extrapolated size–frequency relation for NEOs as determined from crater size–frequencies on the moon and from the large NEOs found by Spacewatch (Rabinowitz, 1992; Rabinowitz, 1993). Compared to the distribution of orbits of the large NEOs, the orbits found for these small objects include an excess of low eccentricities with perihelion near the orbit of the Earth indicating a possible distinct subclass of NEOs which we have called the "Arjuna's" (Rabinowitz, et al. 1993).

Future upgrades in both hardware, software, and telescope aperture may allow an order of magnitude increase in the rate of discovery of NEOs in the next several years. Several of the techniques proposed for the Spaceguard Survey (Morrison, 1992) have already been tested by Spacewatch, and others will need to be tested in the near future before such a survey can be implemented.

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Gas dynamics of a sublimating cometary analogue

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The gas released by sublimation from a cometary nucleus cannot be in thermodynamic equilibrium near the surface because it can only expand into the half-space of the vacuum side. Only after many collisions between molecules of different velocities, many free paths away from the surface, the gas will re-establish a new (drifting) Maxwell-Boltzmann velocity distribution. Huebner and Markiewicz (1992, unpublished) described the velocity structure of such a gas and calculated some essential parameters. But in reality it is difficult to predict the correct velocity distribution. Many poorly known parameters like surface temperature or the size and structure of a dust mantle lying above the sublimating surface modify the primary velocity distribution.

The KOSI collaboration (KOSI = German abbreviation for COmet SImulation) studies the behaviour of ice-dust mixtures (cometary analogues) under simulated space conditions. Within this program we try to determine the dynamics of the sublimated gas which is necessary for an understanding of the gas-particle-interaction. Apart from testing the model mentioned above, one can determine the important factors which influence the velocity distribution and one can support the calculation of the energy balance and of the thermal evolution of a sample.

In order to measure the gas velocity we constructed a device, called gas-chopper, where the gas flow from the sample is periodically interrupted (chopped) and the resulting density variation measured. As the gas has a finite velocity and the distance between chopper and gauge is about 0.2 m we measure time-delayed convolution of the velocity distribution and the interruption profile. The device and the results achieved so far will be described with emphasis on the last KOSI experiments where measured for the first time the velocity distribution at about 1 m distance from the sample surface.

SOCCER MISSION - SCIENTIFIC OBJECTIVES AND STRATEGY

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ISAS and NASA are discussing the possibilities of a cometary mission called SOCCER (Sample of Comet Coma Earth Return) by using a new M-V rocket of ISAS, since 1987. Four workshops have been held in ISAS for this.

Scientific Objectives of a comet mission can be classified into three categories:

1) REFRACTORIES

An essenatial element of the solar system materials is water. Redox states of various terrestrial planets may be determined by the interacton of water wih dust particulers in the solar nebula. Two important isotopic anomalies, those of H and O, could be correlated wiht separation of various isotopicaly different water molecules in the nebula, too. The recently proposed LID (light induced drift) effect [1] might explain these phenomena simultaneously. Oxygen isotopic measurrements of cometary dust particles may contribute to these types of discussions.

2) ORGANICS

Recent establishment of importance of the ribozyme (RNA enzyme) [2] clearly suggests that final targets for the organic study of solar system materials are not amino acids but nucleotides. RNA (a sort of PAH) is an unstable molecule but could be retained in the icy materials. Even poly - (deoxy) nucleotides are all right. Of course, amino acids are also interesting targets, which could be detected with a high sensitivity by the capillary electrophoresis with laser technique [3].

3) VOLATILES

This is difficult to be collected by a SOCCER type mission. A Rosetta type mission is absolutely necessary.

I shall discuss these sciences together with the SOCCER mission description.

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2) J. Watson et al. (1987) Molecular Biology of the Gene, Vol 2. Chapter 28, The Benjamin/Cummings Publ. Comp. Inc.
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THE PALOMAR ASTEROID AND COMET SURVEY (PACS), 1983-1993. Carolyn S. Shoemaker and Henry E. Holt, Northern Arizona University, Flagstaff, AZ 86011; Eugene M. Shoemaker, U.S. Geological Survey, Flagstaff, AZ 86001; Edward Bowell, Lowell Observatory, Flagstaff, AZ 86001; David H. Levy, 120 William Carey Street, Tucson, AZ 85747

The Palomar Asteroid and Comet Survey (PACS) was begun in 1983 as a long-term project to evaluate the populations and fluxes of Earth-crossing and other planet-crossing asteroids and comets. It is a collaborative project between the PACS observing team and Edward Bowell of Lowell Observatory. Observations have been carried out on the 46-cm Schmidt camera at Palomar Observatory by E.M. and C.S. Shoemaker, H.E. Holt, and D.H. Levy with the occasional assistance of students. Well over 10,000 unknown asteroids and about 100 comets have been detected in a total of about 7,000 search fields photographed. Limitations of manpower have precluded measuring and reporting all the objects detected; hence the effort has been focused mainly on the planet-crossing bodies and on asteroids with unusual motion. Astrometric positions have been obtained for about 3,000 unnumbered asteroids. About 7% of these are now numbered; discovery of about 140 of the newly numbered objects is credited to the PACS team. Altogether, 43 Earth-approaching asteroids have been discovered, and about 30 others have been independently detected. Sixty Mars-crossers and about 150 high-inclination asteroids, chiefly Phocaeas and Hungarias, have been discovered. Beginning in 1985, special attention was paid to Trojan asteroids, and 64 Trojans have been found, 47 of which are credited to PACS. Forty-five of the new Trojans have been numbered, a total that exceeds the full set of numbered Trojans at the onset of the survey. Of the comets detected in PACS, 29 are credited as discoveries by members of the survey team; 15 of these are short-period comets. In addition to active comets, several Jupiter-crossing or Jupiter-approaching objects of asteroidal appearance have been found that are almost certainly extinct comets. Although the prime aim of PACS is discovery, astrometric measurement of known objects has led to the improvement of hundreds of orbits and has accelerated the numbering of many asteroids.

The frequency of discovery and independent detection of planet-crossing bodies as a function of the area of sky covered in the systematic PACS survey have provided a foundation for refined estimation of the population of Earth-crossing asteroids larger than about 1 km in diameter, of their flux near the Earth, and of the present cratering rate by asteroid impact on Earth [1]. Collision of asteroids produces most impact craters smaller than 20 km in diameter; the cratering rate estimated from PACS observations is consistent with the geologic record of cratering for the past 120 million years. The PACS discoveries also provided the basis for calculating the asteroid impact and cratering rate on Venus and for estimating the mean age of the Venusian surface revealed in the Magellan radar images [2]. The average age of the surface of Venus was shown to be less than 500 million years.

Henry Holt's discovery of Apollo asteroid (4581) Asclepius = 1989 FC, which missed the Earth by about 1-1/2 times the distance to the Moon on March 23, 1989, substantially increased public awareness of the hazard of asteroid impact. Another discovery made in the course of PACS, by Levy and Holt, was (5261) Eureka = 1990 MB. This asteroid turned out to be a Mars Trojan [3], thus establishing the existence of a new dynamical class.

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THE FLUX OF PERIODIC COMETS NEAR EARTH. Eugene M. Shoemaker, U.S. Geological Survey, Flagstaff, AZ 86001 and Carolyn S. Shoemaker, Northern Arizona University, Flagstaff, AZ 86011

A total of 25 active Earth-crossing periodic comets has been discovered; 12 are in the Jupiter family (J-f) and 13 in the Halley family (H-f). The Earth-crossing H-f comets constitute 62% of the discovered comets of the Halley family. The large majority of the Earth-crossing J-f comets and nearly all the Earth-crossing H-f comets have been discovered visually at small to moderate solar elongations. This is the region where techniques of visual search tend to minimize bias against discovery of high-inclination comets. No H-f comets have been discovered with $q > 1.574$, whereas more than 90% of J-f comets have $q > 1.0$ AU; many are now being found photographically with $q > 2.0$ AU. The average period of H-f comets is much longer than for J-f comets, which results in many fewer perihelion passages and fewer opportunities for discovery for a given period of observations. Moreover, the very broad distribution of inclinations of H-f comets results in a strong bias against discovery by photographic observations, which are concentrated along tlle ecliptic and near opposition. Because of these selection effects, it is inappropriate to compare the raw statistics for total discovered H-f and J-f comets with theoretically predicted distributions.

Present understanding of the history of activity of J-f comets and discoveries of "extinct" comets (bodies of asteroidal appearance on Jupiter-crossing orbits), leads us to expect that the activity of most J-f comets has been quenched by repeated passage substantially nearer the Sun than their current q. To date, 12 candidate extinct J-f comets have been discovered; one of them is Earth-crossing. Shoemaker et al. (1986) estimated, from the set of objects discovered through 1985, that the total population of extinct J-f comets brighter than $B(1,0)=18$ is 1460 ± 650. This number is about 9 times higher than the estimated population of active J-f comet nuclei. However, the mean i of discovered extinct J-f comets is about twice that of the known active Earth-crossing J-f comets. The true mean i of extinct J-f comets must be much higher than that observed, due to observational bias against discovery of high-i objects. The true ratio of extinct to active comets may be roughly 20:1. The current number of active Earth-crossing J-f comet nuclei larger than 1 km in diameter is estimated to be about 40 ± 20, and the number of extinct J-f comet nuclei >1 km in diameter is very roughly estimated at 800. The abundance of extinct J-f comets may be ~40% that of the ordinary Earth-crossing asteroids, and their collision with Earth may account for 10% to 15% of terrestrial impact craters larger than 20 km in diameter.

The number of active Earth-crossing H-f comets must be much greater than the number discovered; completeness of discovery of comets is proportional to the frequency of opportunity of discovery. As the mean period of Earth-crossing H-f comets (89 years) is 16 times longer than the mean period of Earth-crossing J-f comets (5.56 years), discovery of H-f comets should be roughly 16 times less complete than discovery of J-f comets. Mean H for the H-f comets (7.6) is 2.7 magnitudes brighter than the mean for J-f comets (10.3); this difference in mean magnitude is equivalent to a difference in cumulative frequency by a factor of 12. To the same level of completeness of discovery of Earth-crossing J-f comets, there must be roughly 12 to 16 times as many active Earth-crossing H-f comets as have been discovered. Interestingly, this yields a ratio of H-f to J-f comets among the active Earth crossers that is similar to the ratio predicted by Quinn et al. (1990) for periodic comets derived from the Oort cloud, when account is taken of dynamical lifetimes. If the two estimates of completeness of discovery are averaged, the number of active Earth-crossing H-f comets corresponding to the 12 known active J-f comets is very roughly 200.

The ratio of extinct to active H-f comets cannot be determined from observations at the present time, as only one extinct H-f comet, 1991 DA, has been discovered. Thus, we are forced to fall back on theoretical arguments to estimate the number of extinct Earth-crossing H-f comets. Probably nearly all J-f comets, in the course of their dynamical evolution to short period, have passed through a stage of intermediate-period orbits corresponding to Halley family orbits. The steady-state number of H-f comets should exceed the number of J-f comets by a factor equal to the ratio of the dynamical lifetimes of the two families. This factor is roughly equal to the ratio of the mean periods of the two families or about 16:1. This is only a crude estimate, however, because we must also understand the evolution to low q of both H-f and J-f comets. If the ratio of extinct to active H-f comets is of the order of 16:1, the contribution of extinct H-f comets to impact cratering on Earth must be very roughly comparable with that of extinct J-f comets. Together, periodic comets may account for about one-fourth of the production of terrestrial impact craters larger than 20 km in diameter, a fraction about equal to the contribution of long-period comets. Periodic and long-period comets combined probably are responsible for most of the largest impact craters on Earth, including those that may be associated with mass extinctions.

Survey of the Jupiter Trojans

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Six photographic surveys have been done that provide the bulk of our present knowledge about populations and dynamical structure of the L4 and L5 Trojan swarms associated with Jupiter. These include the Palomar-Leiden (PLS), T-1, T-2, and T-3 surveys, all carried out by C.J. van Houtlen and I. van Houtlen-Groenveld and their colleagues with the plates taken with the 1.2-m Schmidt at Palomar in the 1960's and 1970's; a survey by S.J. Bus and colleagues with plates taken on the 0.6-m Schmidt at Cerro Tololo in 1988 and 1989; and a survey of bright Trojans carried out by C.S. and E.M. Shoemaker and colleagues with the Palomar 0.46-m Schmidt between 1985 and the present. The results from these surveys combined with the efforts of other observers has led to the discovery of 278 Trojans; 180 of these now have multiple opposition orbits and 109 are numbered. On the basis of the survey for the bright Trojans by the Shoemakers, discovery is now thought to be essentially complete to $H = 9.5$. Extrapolation to $H = 13.5$ from the surveys for faint Trojans suggests that the population of Trojans larger than 15 km in diameter is about 2000 in the L4 swarm and about 1400 in the L5 swarm.

In an attempt to relate the current structure of the Trojan swarms to their formation and subsequent dynamical evolution, we have undertaken to map the stability field of Trojans in the coordinates proper eccentricity, e_p, and libration amplitude, D. To accomplish this mapping, we integrated numerically the orbits of 110 particles with e_p in the range 0 to 0.8 and D in the range 0° to 140° for a billion years. We find that with increasing time the stability field shrinks in both e_p and D. A surprising result is that a significant number of Trojans lie outside the region of one billion year stability. About 8% of the Trojans are unstable on this time scale. The Trojan swarms are dissipating with half-life of the order of the age of the solar system. Particularly unstable Trojans were lost early in solar system history, and the early Trojan swarms must have been many times more massive than the present swarms.

CHON-PARTICLES AS A POSSIBLE SPREAD SOURCE OF MOLECULES IN THE INNER COMA OF COMET HALLEY. L. M.Shulman, Main Astronomical Observatory of the Ukrainian Academy of Sciences, Kyiv, 252127, Ukraine.

There is evidence that a spread source of volatiles exists in a comet coma except the surface of its nucleus, which is the usual source of parent molecules. Sometimes the anomalous distribution of brightness is observed in the inner comas. It rarely looks like the ring structure, because most volatiles are vaporized from the nuclear surface and the additional source may be too weak to make sufficient contrast on the image of the comet. Recently, in the VEGA-GIOTTO missions to Comet Halley, cyanogen jets were detected and these jets accompanied the dust ones so as dust produced CN.

Nazarchuk [1] has found in the Comet Halley spectra the inverse dependence of the intensities of different emission on the nucleocentric distance. It may be caused by the jets, but it is strange that this phenomenon occurs on different dates approximately at the same nucleocentric distances and those distances are different for different species.

A possible reason of the effect is proposed and analyzed. To explain the inversion of the space distribution of a comet gas one needs an additional source of this gas, which is most intense at some distance from the nucleus. Dust particles of the appropriate chemical composition can be proposed as this source. The question is, what can delay their sublimation until they reach the definite nucleocentric distance?

The hypothesis is discussed that the evaporation of the grain should be enhanced abruptly when surface tension takes the participation in the process of sublimation of the grains. The equation of sublimation of small particles really has an "explosive" solution that gives the spread source of volatiles. This source would be localized at some sphere around the comet nucleus and very close to it. The necessary conditions to explain the observed facts are discussed.

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The Giacobinids 1985
Canadian radar observations

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Fine structure profiles of the Giacobinids 1985 derived from the Ottawa megawatt meteor radar are presented. Recorded meteor echoes were divided for the analysis into two basic groups: underdense represented by meteor echoes having durations $T<0.4$s and overdense one with $T\geq0.4$s. Maximum activity occured at 09h 25m UT when ten minute zenithal rate reached about 1157 in underdense range and about 669 overdense echoes at 10h 25m UT.

The Perseid Meteor Stream Observed Before Return of Comet P/Swift-Tuttle in 1992

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The nature of Perseid meteor shower activities in 1991 and 1992 is characterized by high shower rates placed around the solar longitude of 138.8° (1950.0). Such a position of maximum activity is well before that one observed regularly in this century. Considering the ejection velocities of the particles from parent comet it was found that the ejection took place during previous passage of the comet through its perihelion in 1862.

LINKAGE OF ALL THE APPARITIONS OF COMET P/WOLF

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We collected 596 observations from 14 apparitions of the comet during 1884-1992. Equations of motion of the comet have been integrated by the recurrent power series including all the planetary perturbations. We also took into account nogravitational effects in the comet's motion using the known Marsden's method but with the four parameters A, η, I, ϕ connected with the rotating nucleus of the comet; a precessional motion of the spin-axis of the comet's nucleus was taken into account by determinig the linear daily change of the angle ϕ. Thus it was possible to link all the observations of the comet with the RMS residual equal to $1.''65$.

Orbital evolution of Jupiter's 8th satellite

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The orbital evolution of Pasiphae — 8th satellite of Jupiter has been investigated. Its osculating orbit for an epoch 1938 October 29 was numerically integrated within the interval $\pm 20,000$ years. As commencing data for the integration process the Grosch's jovicentric elements of the 8th satellite were used. There are differences between the 8th satellite's motion in a dynamical model of the solar system consisting of all planets, and in a model with Jupiter and Sun only. Solar perturbations are presented on changes of the satellite's osculating elements with time. The difference between the three-body and n-body solution of the satellite motion is demonstrated by the changes of the radius vector of the satellite.

The orbit of the satellite is continuously changed due to great Sun perturbations. Within the investigated period the eccentricity of the satellite's orbit changes periodically from 0.18 to 0.66, the inclination from 140° to 156°. The orbit is circular. Its perijove rotates with the period of ~ 102 years, and the node with ~ 80 years.

Within the investigated time interval also the question of the Hill's stability has been studied. The Jacobian constant calculated from positions and velocities obtained by numerical integration, changes less than the order of 10^{-8}. It is known, that the surface of zero velocity is closed around Jupiter, when the Jacobian constant of the satellite is greater than the Jacobian constant of the inner point of the libration. In our case, the Jacobian constant of the satellite is greater than the value of the Jacobian constant for that outer point of libration, which is nearer to Jupiter. Therefore, the motion of the satellite can be inside of the close surface around Sun-Jupiter region.

The presented dominant perturbations of Sun to the satellite allow to use the intermediate orbit of the averaged elliptic three-body problem for investigation of the evolutionary changes in the motion of the satellite. The mean motion of the node and the perijove of the satellite are defined by analytical formulae, using the osculating non-Keplerian ellipse with moving node and perijove, and changing eccentricity. The results obtained by this theory are comparable with those calculated from the numerical integration.

The Thermal Emission of 4179 Toutatis from 150 to 6 Degrees Phase Angle

J. R. Spencer (Lowell Observatory), J. P. Emerson (Queen Mary and Westfield College, Univ. London), D. J. Tholen (Univ. Hawaii), C. Skinner (Lawrence Livermore), M. Meixner, J. Graham (U.C. Berkeley), D. Walther (Joint Astron. Center), A. Ghez (Univ. Arizona), H. Campins, D. Osip (Univ. Florida), G. Rieke and M. Rieke (Univ. Arizona)

The Toutatis flyby of Earth in December 1992 provided a unique opportunity to observe the thermal emission from an asteroid over a very large range of phase angles. The high-resolution radar observations of Ostro *et al.* also provided unique "ground truth" to assist in interpretation of the telescopic data. Emerson, Skinner, Meixner, Graham, Walther, and Ghez observed Toutatis from the U.K. Infrared Telescope on Mauna Kea using the 10-micron Berkeley Infrared Camera. First observations were at 12 μm at 17:45 UT on Dec. 6, at an unprecedented phase angle of 150.5°, and on subsequent days Toutatis was observed at phase angles down to 56° at wavelengths between 8.5 and 11.8 μm. Campins, Osip, Rieke, and Rieke obtained a 10 μm flux on December 17 UT at 50° phase from the Steward Observatory 2.3m telescope on Kitt Peak. On January 11 and 12 UT Spencer and Tholen observed Toutatis at 6.7–5.8° phase angle at 8.7–20 μm wavelengths from the NASA Infrared Telescope Facility on Mauna Kea, with near-simultaneous visible-wavelength photometry. The preliminary thermal phase curve is shown below.

Interpretation of these observations is still preliminary because as of March 1993 the sidereal rotation period, pole orientation, and dimensions of Toutatis are still poorly known. However, the low phase angle January observations are expected to be fairly well described by the Standard Thermal Model (STM), which assumes surface temperatures in equilibrium with sunlight and includes an empirical correction for surface roughness. Because of the several day rotation period, large deviations from equilibrium temperatures are unlikely for the sunlit regions seen at these low phase angles, even for a very high thermal inertia surface. Also, though the STM assumes a spherical body, shape effects such as shadows should be minimised at low phase angle and the STM should yield a reasonable estimate of the projected surface area. However, interpretation of the January thermal and visible data with the STM gives an effective diameter of 2.0 km on 1/11, and 2.5 km on 1/12, with a geometric albedo of 0.24. This is smaller than the preliminary radar diameter estimates of about 4km, and we do not yet know the cause of this discrepancy.

We have attempted preliminary interpretation of the higher phase angle observations with a spherical rough-surface thermophysical model with a variety of thermal inertias. Despite the long rotation period, the high phase angle data, which samples thermal radiation from the night side, is quite sensitive to thermal inertia. Attempted model fits are shown in the figure. Clearly more sophisticated models are needed, but these must await better data on Toutatis' shape and rotation. Current models suggest a relatively high thermal inertia, however.

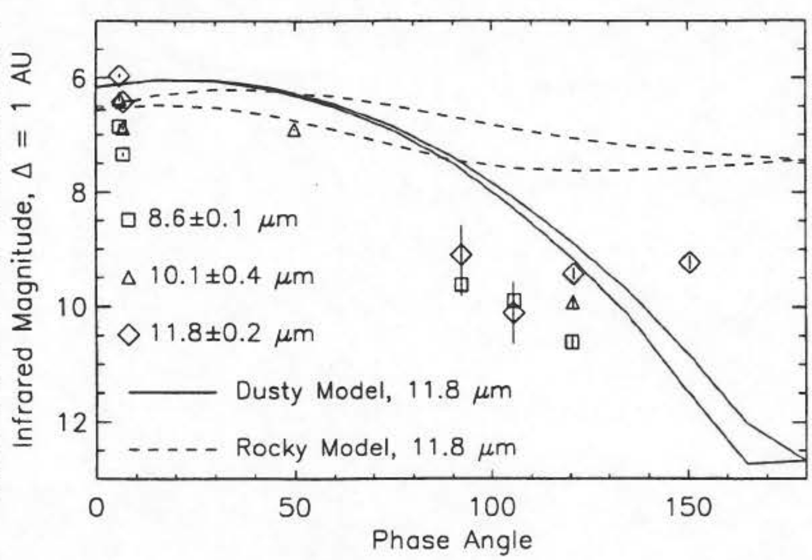

Figure: Comparison of multi-wavelength Toutatis thermal phase curve with rough-surface thermophysical models. Observations at slightly different wavelengths have been combined. The models assume a sphere of diameter of 2.2 km with the sun and earth in the equatorial plane, a rotation rate of 10 days, a bolometric albedo of 0.1, and a surface roughness comparable to main belt asteroids. An approximate correction for the changing heliocentric distance has been applied. The "Rocky" model has a thermal inertia of 2×10^6erg cm^{-2} s$^{-1/2}$ K^{-1}, and the "Dusty" model thermal inertia is 5×10^4.

Recent Fireballs Photographed in Central Europe

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The atmospheric trajectories, velocities, brightnesses and orbits of exceptional fireballs photographed in Central Europe during last three years are presented. The operation of Czech part of the European Fireball Network is briefly described.

METEOROID STREAMS

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Meteoroid streams, producing meteor showers if some part of the stream has a node near 1 AU, have complex structures which are only just beginning to be understood. The old simplistic idea of a narrow loop being formed about the orbit of a parent comet with one, or possibly two, terrestrial intersection(s) is now being replaced by the recognition that their dynamical evolution may render convoluted and distorted ribbon shapes with up to eight distinct showers being generated. As such the streams are excellent tracers of the sorts of orbital evolution which may be undergone by larger objects (asteroids and comets) in the inner solar system; indeed it is now known that objects now observed as Apollo-type asteroids may also be the progenitors of meteoroid streams.

Searches for showers associated with newly-discovered possible parent objects may be carried out either via the calculation of theoretical meteor radiants (which have hitherto been derived using an untenable method) or through searches of catalogs of individual meteor orbits. In order to accomplish the latter, about 68,000 radar, photographic and TV meteor orbits from various programs in the U.S.A., the former Soviet Union, Canada and Australia are available from the IAU Meteor Data Center, and more than 250,000 orbits of very faint meteors have been determined over the past three years using a new facility in New Zealand.

The discovery amongst IRAS data of dust trails lagging behind comets has opened up a new way in which meteoroid streams may be investigated, although the relationship between these trails and the streams observed as meteor showers at the Earth is by no means clear at this stage. Similarly radar, radio and spacecraft impact observations of meteoroids near cometary nuclei have added to our knowledge.

In spite of the improvement in our understanding of meteoroid streams over the past few years it is clear that there is much still to be done. The words of W.F. Denning in 1923 are still pertinent: "Few astronomers occupy themselves with the observation and investigation of meteors, and yet it is an attractive field of work offering inviting prospects of new discoveries".

THE SMALL COMET HYPOTHESIS: SUPPORT FROM RADAR METEORS?

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In a well-known and much-debated series of papers Frank *et al.* have suggested and defended their hypothesis that the Earth is struck every few seconds by mini-comets of mass ~100 tonnes, based upon satellite data apparently showing brief UV obscurations of limited areas of the upper atmosphere. One of the major pieces of supporting evidence that Frank *et al.* claim for their phenomenon (if real and not an instrumental artifact) having an extraterrestrial origin is the apparent agreement between the obscuration rate and the diurnal and seasonal variation in radar meteor counts. This has not been challenged in previous criticisms of the hypothesis (see A.J.Dessler, *Rev. Geophys.*, **29**, 355–382, 1991) and indeed has been cited as being strong evidence in favour of the small comet hypothesis. In this paper we show that the particular radar data used by Frank *et al.* were not representative and that an unbiased selection from available meteor data does not *quantitatively* substantiate their claims. In spite of this we believe that they have indeed identified a previously-unrecognized phenomenon with a source in the meteoroidal complex, and we give an alternative model for its origin and temporal variation.

Collisions in the Kuiper Disk

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We have constructed models of the collision rates between cometary bodies in the present-day Kuiper Disk (KD) under various assumptions about the total mass and the distribution of orbital (a,e,i) elements in the Disk. These calculations demonstrate that significant collisional evolution can take place in the Kuiper Disk. By computing the optical depth of debris created from collisions in the KD, our calculations reveal that the present-day radial mass distribution of the solar system undergoes a sharp discontinuity (or edge) at Neptune. That is, we can demonstrate that the Kuiper Disk is not massive compared to Neptune. Based on this result, we conclude that either the primordial solar system's mass distribution was similarly truncated near 30 AU, or subsequent collisional/dynamical evolution has depleted the 30-100 AU zone by several orders of magnitude. We will report on these results and a model predicting the detectability of thermal-IR emission from collisionally-produced dust in the Kuiper Disk.

Numerical Simulations of Particle Orbits Around 2060 Chiron

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Scattered light from orbiting or co-orbiting dust is a primary signature by which Earth-based observers study 2060 Chiron's activity and atmosphere. Therefore, it is important to understand the lifetime, dynamics, and loss rates of this dust. We report here on dust coma simulations in which the motion of over 18,000 coma particles under the influence of Chiron, the Sun, and solar photon radiation were followed by direct numerical integration. These simulations indicate that particles ejected from Chiron are more likely to follow suborbital trajectories, or to escape altogether, than to enter quasi-stable orbits. Indeed, orbits with lifetimes of days-to-weeks can only be achieved for very specific launch conditions in discrete regions of parameter space. Further, we found that when particles do enter orbit, their lifetimes are short (typically hours-to-days), with a practical (i.e., >98%) limit of <100 days. Finally, we found that there are important size-dependent particle-lifetime effects which may be related to reported variations in Chiron's coma color. Our simulation results show (i) that short timescale changes in the photometric brightness of Chiron's dust coma can be used to directly study both the outburst properties and timescales of Chiron's nuclear source(s), and (ii) that it may be possible to use radial structure in Chiron's tail to constrain the rates and behavior of nuclear sources on much longer timescales.

Complexes of the Associated Meteoroids, Asteroids and Comets

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Search for associations between meteoroids and asteroids based on orbital comparison has lead to the conclusion about the existence of closely associated complexes consisting of one or more asteroids on the one hand and of several meteoroids concentrated into one or more streams on the other hand. As a prototype of this kind of complex is the Taurid complex consisting of comet P/Encke, a few asteroids (2201 Oljato, 5025 P-L, 1984 KB and 1991 BA at least) and several meteor streams (Northern and Southern Taurids, Northern Piscids, Southern Arietids, Northern and Southern Chi Orionids, Ro Geminids). Evidence is presented in favour of the reality of some other complexes of meteoroids, asteroids and comets, with the asteroids 4179 Toutatis, 1980 AA, 1989 VB, together with 4015 (1979 VA), 3671 Dionysius and some others as their prominent representatives. Conclusion about these complexes are in perfect agreement with Drummond's asteroid streams, and to some degree also with Obrubov's minor body complexes. The consequences of the results and the nature of the comet-asterois-meteoroid complexes are discussed.

NEW APPROACHES TO MAPPING COMPLEX SHAPES: Philip J. Stooke, Dept. of Geography, University of Western Ontario, London, Ontario, Canada N6A 5C2 (stooke@vaxr.sscl.uwo.ca).

Comet and asteroid science is moving into an era of disk-resolved studies in which cartography is both possible and necessary. Maps will help register multiple data sets, give a global perspective and provide bases for maps of geology, albedo etc. The range of possible shapes which may be encountered suggests that new approaches will be needed to produce the most useful maps **[1-3]**.

Conventional map projections are based on the sphere and cannot be conformal (preserve true shape) and equivalent (preserve area relationships) at the same time. This is not true for any object composed of approximately plane, conical or cylindrical surfaces. A roughly cubic asteroid could be mapped on six orthographic views normal to its facets which (unlike orthographic projections of a sphere) would be both equivalent and conformal. Maps of the facets could be printed side-by-side, joined on any common edges, and easily folded to create a 'cubic globe'. This applies to any shape composed of plane facets (tetrahedron, 'brick-shaped' cuboid). An object approximating a cylinder with flat ends could be mapped on a form of cylindrical projection with azimuthal projections for the ends. With appropriate projection parameters the maps could again be both equivalent and conformal, and could be easily assembled into 'cylindrical globes'.

More exotic shapes introduce new challenges. How should a contact binary be mapped? Images of 4179 Toutatis and an occultation profile of 216 Kleopatra **[4]** (possibly triple) make the question no longer academic. Two distinct objects orbiting their barycentre would be mapped separately, each with its own coordinates. A long shape with a shallow 'waist' would be mapped as one object. Intermediate objects may be just in contact or have narrow waists with varying amounts of debris in the contact zone. How much waist is needed for the object to be mapped as one? How are coordinates defined if the axis lies in a narrow waist? (**Fig. 1**). Cases must be decided individually. Three objects could merge into a multilobate shape with a thin central region containing the rotation axis (**Fig. 2**). Experiments (**Figs. 1, 2**) suggest that conventional planetocentric coordinates work even for these shapes, with least distortion and best depiction of shape if areas of maximum curvature are near the outer edge of the map. Maps are least distorted if the body is divided by the plane minimizing total distance to the major radius maxima and the projection is morphographic **[2]**, centred at the 'poles' of the dividing plane. The sinusoidal projection **[5]** is good for data storage and manipulation but poor for representation.

Comets could pose more serious problems. A nucleus with a polar active region could evolve into a torus. Longitude would be easy to define but there would be no poles. Latitudes could be measured from 0° to 360° around the cross-section of the torus. Longitude and 'torus latitude' could be plotted as a grid which could be made equivalent or conformal (but not at the same time). Maps of the north and south sides of the torus, resembling a polar azimuthal projection with a hole in the middle, could be made equivalent or conformal in some cases (not yet fully explored). Tori are likely to be fragile, hence rare, so detailed treatment is not yet needed.

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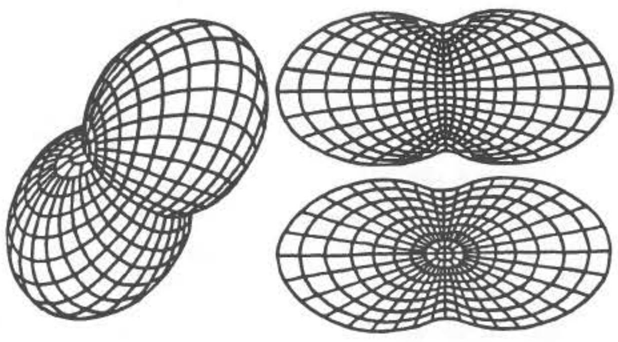

Fig. 1: Binary object in orthographic (left) and morphographic equidistant (right) projections.

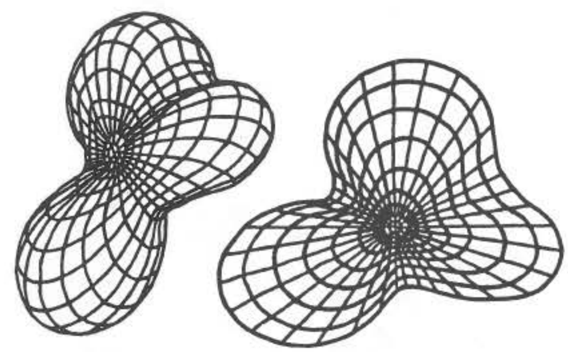

Fig. 2: Triple object in orthographic (left) and morphographic equidistant (right) projections.

Gaseous Jets of P/Hartley 2

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Hiroshi Kurihara (Kanagawa Industrial High School)
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CCD imaging observations of P/Hartley 2 were carried out with 188cm reflector on August 12-15 1991. Four narrow-band filters were used for C_2, CN emissions and their corresponding continuum. After processing their images carefully by applying azimuthal enhancement technique, we obtained asymmetric coma structure as shown in Fig. 1. Furthermore, we found a difference in radial profiles between the enhanced region of coma and the background. These results indicate an existence of gaseous jets of C_2 and CN components in P/Hartley 2. We discuss about the structure of the gaseous jets in this paper.

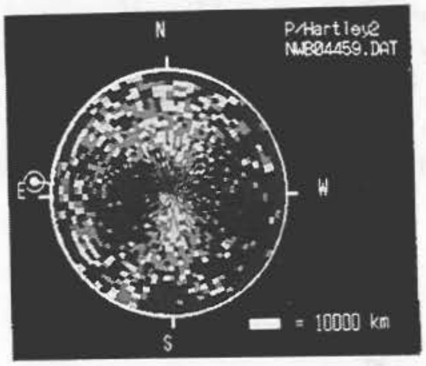

Fig.1-1 Processed image of C_2.

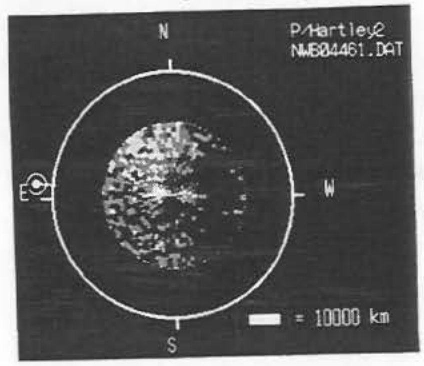

Fig.1-2 Processed image of CN.

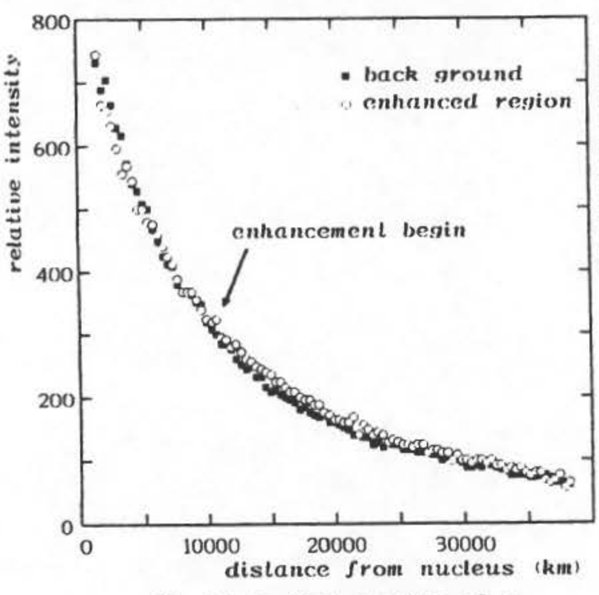

Fig 2-1 Radial profile of C_2.

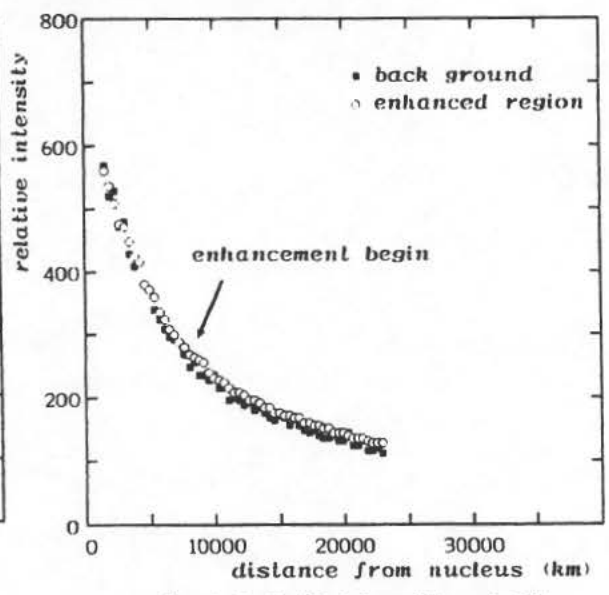

Fig 2-2 Radial profile of CN.

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Photometry of Comet P/Brorsen-Metcalf at the Skalnaté Pleso Observatory

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The analysis of the pre-perihelion photoelectric measurements of P/Brorsen-Metcalf made at the Skalnaté Pleso Observatory is presented. The photoelectric measurements of P/Brorsen-Metcalf in August 1989 were carried out with IHW/IAU filters CN, C_2, C_3, CO^+, $Cont.365.0$ and $Cont.484.5$. Two focal diaphragms, 49.0" and 220.5" in diameter, were used. The magnitudes, fluxes and total numbers of molecules are presented.

The results with the values of P/Halley at equal heliocentric distance, obtained with the same method and instrument, are compared. P/Brorsen-Metcalf emitted considerably less molecules in the same column of the coma than P/Halley. The ratios in the $CN - emission$ and $C_3 - emission$ are 1:91 and 1:23, respectively.

Correlation of CN with dust was confirmed.

The photoelectric C_2-magnitudes in the larger diaphragm agree with the mean values of the total visual estimates.

CONNECTION BETWEEN NONGRAVITATIONAL AND ROTATIONAL MOTION OF COMET P/KOPFF

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ABSTRACT

The orbital and rotational motion of periodic comet Kopff was investigated using observations made during its 12 returns to the Sun. To correct orbit of the comet a model of nongravitational effects varying with time was used. The magnitude of the nongravitational acceleration was computed from the variation in the sublimation rate with position of the comet in orbit. The sublimation rate derived from light curves was taken from Sekanina's paper (1984, *AJ* **89**). Direction cosines of the nongravitational acceleration in orbital coordinates depend on the lag angle, the equatorial obliquity of the cometary nucleus and the cometocentric longitude of the Sun. These angular parameters and orbital elements are calculated from observational equations in iterative process of the orbit improvement.

Scaling Law on Fragment Velocities of Catastrophic Impacts

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I. Introduction

Velocity distribution of fragments produced by catastrophic collisions of planetesimals has significant effect on the protoplanet growth. Recently some experimental researches to this problem have been performed (e.g., *Nakamura and Fujiwara*, 1991; *Nakamura et al.*, 1993; *Takagi et al.*, 1991; 1992). In these papers the point of discussion was the velocity dependence on the fragment mass (*Nakamura and Fujiwara* (1991) suggested that the fragment velocity is proportional to $m^{-1/6}$, whereas *Takagi et al.* (1991; 1992) indicated that the fragment velocity is independent of the fragment mass). Although the clarification of the dependence may provide some explanation on the fracturing process of catastrophic impacts, general scaling law on the velocity distribution is required for the elucidation of the planetary growth problem. In this paper we report some results on the general law on velocities of fragments produced by catastrophic impacts.

II. Experimental Methods

Impact experiments were performed by a single-stage powder gun at Nagoya University. Projectiles of cylindrical aluminums were impacted to targets of cubic pyrophyllites horizontally in the velocity range of 428 to 908 m/sec. Motions of fragments were recorded by a high-speed motion camera in 1500 frame/sec. Four mirrors were set in front of the lens to obtain the stereographic picture of the fragment motions. The three-dimensional velocity of each fragment was determined by the least-squares fitting of the three-dimensional position in the successive frames. Target reconstructions were performed using recovered fragments. The distance from the impact point to the initial position of each fragment was measured.

III. Results

Result from a single run shows that the fragment velocity, v, negatively correlates with the distance from the shot point to the initial position of fragment, r; $\log(v/v^*) \propto -0.8 \log(r/L_p)$. In this equation the fragment velocity is normalized by the characteristic velocity of the target material (*Mizutani et al.*, 1990), $v^* = Y/C_0\,\rho$, where Y, C_0, and ρ are the strength, bulk sound velocity, and density of the target, respectively. The distances are also normalized by the dimension of projectile, L_p. Results of all runs indicate the correlation with almost the same coefficient $(-0.74 \sim -0.87)$. However the average velocity of each run correlates with the Nondimensional Impact Stress (NDIS) as already shown by *Takagi et al.* (1991; 1992).

All the results show that the velocity is simply proportional to the shock wave pressure at the initial position of fragment, $P(r)$. The least-squares fitting gives the following relation; $\log(v/v^*) = 0.094 + 0.27 \log(P(r)/Y)$, where Y is the compressive strength of target material. The pressure was calculated by the equation; $P(r) = P_0\,(L_p/r)^\alpha$, where P_0 is the initial shock pressure calculated by Rankine-Hugoniot equation. The decay coefficient α was assumed to be 3.0.

IV. Summary

The present experimental results show that fragment velocities are expressed by a simple equation using the shock wave pressure at the initial position of a fragment. This equation could not be derived straightforward from the scaling law using the NDIS parameter (*Mizutani et al.*, 1990). However this result suggests that the shock wave pressure in a target is the key parameter for the velocity distribution of impact fragmentation phenomena.

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Radar measurements of very high velocity meteors by AMOR.

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Approximately one percent of the meteors detected by the Christchurch meteor radar, AMOR occur almost simultaneously on all three receiver sites indicating velocities on the order of hundreds km/s. Previous meteor radars relying on Fresnel diffraction methods for velocity determination are precluded from measuring such high values by aliasing problems associated with the sampling rate. There is considerable evidence for this aliasing within the recorded AMOR echo amplitude profiles.

The AMOR high velocity sample has a mean ionisation height 7 km above that for more typical speeds indicating a mean speed of 140 km/s. Other velocity estimation methods also indicate very high speeds. These include: The shift in detected elevation angle as the meteor approaches its specular reflection point, the rate of change in amplitude as the meteor moves past the specular point and the shift in elevation angle for echoes from the rapidly decaying high altitude meteors.

Particle diameters are typically in the range 20–50 μm for these very high velocity meteors. The radiant distribution in right ascension is consistent with particles from an interstellar origin, however the geographical location and beam configuration of AMOR conspire so as not to exclude the possibility of an interplanetary source.

The evolution of particles away from the IRAS dust bands.

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The IRAS observations of dust bands in the asteroid belt have been explained by dust in the orbits of the Eos, Koronis and Themis asteroid families. Assuming this is the source of dust in the bands we consider the subsequent evolution of dust Sunward. When the dust is first released radiation pressure will insert the new meteoroid into an orbit with its semimajor axis larger than the source asteroid. Poynting-Robertson drag will act to shrink (and slowly circularise) the orbit until the orbital period matches that of the next Jupiter resonance. The low eccentricity of the meteoroid orbit at this interior resonance may lead to a rapid increase in eccentricity thereby increasing the effect of Poynting-Robertson drag while shifting the aphelion toward larger heliocentric radii. A meteoroid that makes this resonance jump (with its increased eccentricity) has a much reduced probability of reacting to a subsequent resonance and could therefore continue an uninterupted Poynting-Robertson infall toward the Sun. The distribution of spatial density associated with this jump will tend to concentrate particles at heliocentric radii just outside the circular equivalent of the resonance. Results from the Ulysses dust detector through the asteroid belt suggest such concentrations may exist; a tentative *in situ* detection of the IRAS dust bands by Ulysses.

Main Belt Asteroids (Present Population)

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Main belt asteroids are those with orbits wholly within the orbits of Mars and Jupiter. It is here where the vast majority of the asteroids are located. During the past three years our knowledge of these objects has increased through detailed studies of several of the largest asteroids as well as survey-type investigations of significant numbers of, mostly smaller, asteroids. I have restricted the scope of this review to summarizing and synthesizing investigations directed primarily toward understanding the physical properties of main-belt asteroids.

Studies on large main-belt asteroids published between early 1990 through 1992 include a definitive determination of the size and shape of 2 Pallas by Dunham *et al.* (1990, *Astron. J.* **99**, 1636), lightcurve studies of 4 Vesta by Rock and Hollis (1990, *J. Brit. Astron. Assoc.* **100**, 17), 14 Irene and 51 Nemausa by Belskaya and Dovgopol (1992, *ACM 91*, 45), and of 34 Circe, 98 Ianthe, 115 Thyra, 174 Phaedra, 270 Anahita, 389 Industria, 419 Aurelia, and 804 Hispania by Magnusson and Lagerkvist (1991, *Astron. & Astrophys. Suppl. Ser.* **87**, 269). A new determination of the mass of 1 Ceres was published by Williams (1992, *ACM 91*, 641). A paper presenting millimeter and sub-millimeter observations, and their interpretation, of 4 Vesta by Redman *et al.* (1992, *Astron. J.* **104**, 405).

Photometric studies of small asteroids (i.e., diameters ≤ 50 km) were published by Schober and Stadler (1990, *Astron. Astrophys.* **230**, 233), Wisniewski (1991, *Icarus* **90**, 117), and Barucci *et al.* (1992, *Astron. J.* **103**, 1679). Investigations of spin vectors and (usually) shapes for several dozen asteroids were also published during this period (Magnusson, 1990, *Icarus* **85**, 229; Drummond *et al.*, 1991, *Icarus* **89**, 44; Kwiatkowski and Michałowski, 1992, *ACM 91*, 333; Michałowski, 1992, *ACM 91*, 417).

Two second-generation updates to major data catalogs of, mostly main-belt, asteroids were published in this time frame: The *Asteroid Photometric Catalogue* (Lagerkvist *et al.*, 1992, Uppsala Astronomical Observatory) and the *IRAS Minor Planet Surve Catalog* (1992, Tedesco *et al.*, National Space-Science Data Center).

My review will show how these studies, together with previous work, provide a reasonably complete picture of the distributions, sizes, and general shapes and compositions, of large main-belt asteroids. At the same time, they also offer tantalizing glimpses into possible differences in the physical properties of smaller main-belt asteroids.

METEOR STREAMS OF THE MARS FAMILY

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In view of the future investigations of Mars by means of spacecrafts the studies of the meteor situation in the vicinity of this planet's orbit is of much importance. For this purpose, first of all, meteor streams approaching the Mars's orbit in their orbits' nodes at $\leq 0{,}2$ AU have been revealed. It is found that the meteor situation in the region of Mars's orbit is determined by about 70 meteor streams (by photographic data). Some of these streams consist of large meteor bodies which produce fireball showers and, therefore, may be a more serious danger for spacecrafts, than ordinary meteor streams. Conditions of Mars's encounter with some of the meteor streams are studied: the shortest distances between the orbits and the duration of the approaches are defined.

A possible mechanism of the formation of meteor bodies' orbits with aphelion near Mars orbit is considered. Such orbits are shown to occur as a result of single close encounters between the inner planets and minor bodies moving along the orbits with aphelion distances $q' \leq 4{,}2$ AU. In computing scheme the Laplace method of the unperturbed problem of two bodies was used.

The Shape and Surface of Gaspra

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Gaspra is a highly irregular object with principal diameters of 18.2, 10.5, and 8.9 km, and a mean radius of 6.1 km. The mean radius, axial ratios, and pole orientation derived from the Galileo data agree closely with values inferred from groundbased observations. Assuming that the mass distribution is homogeneous, the rotation axis (RA = 9.47°, Dec = +26.7°) is aligned with the maximum moment of inertia. Gaspra's shape is defined in part by three extensive flat areas and two large, shallow concavities some 9-10 km wide. One of the flat areas is about 6 km across, and defines a plane within $\pm$ 0.2 km. In terms of limb roughness and the size of concavities, Gaspra's shape does not differ markedly from those of some small satellites.

Grooves, linear depressions and aligned rows of pits occur widely on the region of Gaspra seen at the highest resolution (54 m/pxl). These features strongly suggest disturbance of loose material of at least several 10's of meters depth, most likely by fracturing. Ridges, some of which parallel grooves, and one of which transects an impact crater, also suggest some faulting or deformation along preferred directions in Gaspra.

Refined analysis of imaging spectral data (400 to 1100 nm) reveals small but significant color variations over the asteroid's surface, variations that indicate a subtle heterogeneity in surface composition. The average albedo of Gaspra's surface is 0.23 near 500 nm. The heterogeneity may result from downslope movement of surficial material, but Gaspra does not show the evidence for long distance movement of materials over the surface as does Deimos. The interpretation of grooves being formed in loose material implies that regolith is present in both high and low regions of Gaspra.

Craters on Gaspra can be divided into two categories: a very subdued, apparently older population, and a population of much crisper (younger?) craters. The latter is characterized by an index (exponent of the differential power law describing the distribution of crater diameters) of -4.3 $\pm$ 0.3, appreciably steeper than the theoretically derived value of -3.5 expected for collisional equilibrium.

The continuity of structural features such as flat surfaces, ridges, and grooves over the length of the asteroid suggests a body-wide structural grain. This continuity of structure is consistent with Gaspra being a single object derived from a substantially larger precursor body by collisions; it is difficult to reconcile with hypotheses that Gaspra is a binary or a collection of smaller bodies.

On the Possible Genetic Relationship for Icarus Group of Asteroids.

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As it follows from our previous work all Near-Earth asteroids with known rotation periods P and diameters D are conditionally divided on four groups. For each group the ratio D/P is nearly constant. More pronounced group includes nine asteroids and Icarus is first asteroid in this list. And so this group of asteroids will be named Icarus group below.

In the present paper the relations between various physical and dynamical parameters for the Icarus group are studied in detail in order to clear up a question about the possibility of genetic connections between the members of this group. In particular, the taxonomic typies, the UBV colors, albedos, the osculating orbital elements and the proper elements are considered. The comparison with the distributions of the analogous values for the asteroids from famous Koronis family is fulfiled.

ABLATION OF METEOROIDS

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We have carried out the numerical solution of a system of three differential equations, describing drag, heating and ablation of a single non-fragmenting meteoroid. All main effects - the thermal radiation, sputtering, evaporation, deceleration and heat capacity have been taken into account in these computation. The heat conduction process was also taken into consideration for meteoroids with radii greater than critical.

The ionization and light curves were calculated with various combinations of the variable values four fundamental parameters: the preatmospheric velocity V, cos z, the initial meteoroid mass M and the meteoroid bulk density δ. From the analysis of numerical results we have obtained the relation between the maximum light height Hm and variables (M, V, cos z, δ). In particular for cos z = 0.667 and δ = 3.5 g/c c we have find:

$$H_m = 37.55 + 26.74 \log V - 3.86 \log M + \Delta H, \quad (M \geq M*),$$
$$H_m = 40.62 + 34.46 \log V - n \log (M/M*) + \Delta H, \quad (M < M*), \qquad (1)$$

where $M* = 0.16 / V^2$, $n = 2.0 + 0.01\ V$, $\Delta H = 28 \exp(-0.2\ V)$, $\log x = \log_{10} x$, Hm is in km, M is in grams and V in km/s. For small of meteoroids ($-7 \leq \log M < \log M*$) $n < 3.86$ for efficient cooling by radiating.

The analysis of heights was made for two sets of data: the A group of 98 TV meteors (Sarma and Jones, 1985) and 132 the A group meteors in the Super-Schmidt data (Hawkins and Southworth, 1958). In the first play we have reduced the heights Hm to the standard value cos z = 0.667. Then meteors were divided into intervals of velocities and for every interval the mean values heights and velocities were found. Equation (1) has been used to calculate mean values of mass within each group. The average values <M> are independent of V and practically the same in both sets of data. From the analysis we can come to the following conclusions: 1) In the magnitude range from +6 to +1 the main mechanism ablation of the A group sporadic meteoroids is its fragmentation to particles of roughly equal masses. 2) The mean masses of fragments (about 0.002 g) independent of initial mass and velocity of the parent body.

Unless the meteoroid mass is small (M < 0.002 g), equations (1) gives approximately the dependence of Hm on velocity and mass. For values of M between 0.002 and 0.1 g a better approximation is

$$H_m = 48.24 + 26.74 \log V + \Delta H.$$

We see that Hm is independent of M (Bel'kovich and Tokhtas'ev, 1974).

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METEOROIDS FROM COMETS AND FRACTAL CLUSTERS

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The analysis of heights of the C group sporadic TV and Super--Schmidt meteors was made. The variation of height of maximum light H_m with initial velocity V and mass M (for $\cos z = 0.667$) can be described by the next equations:

$$H_m = 40.6 + 2(17.23-n)\log V + 5.555\, n + \Delta H, \qquad M_o \leq M < M_c, \tag{1}$$

where $n = 2.0 + 0.01\, V$, $\Delta H = 28 \exp(-0.2\, V)$, $\log M_o = -6.35$, $\log M_c = 3.08 - 3.26 \log V$, H_m is in km, V is in km/s and M_o, M_c in grams.

For values of M smaller than M_c the height of maximum light is independent of mass (Bel'kovich and Tokhtas'ev, 1974). This independence H_m from M can be explained if we would assume that meteoroids of the C group are of cometary origin and in the range of size $2R_o < 2R < 2R_c$ have fractal structure. If meteoroid radii are in the above mentioned range then the mean bulk density of meteoroids is given by the equation

$$\delta(R) = \delta_o (R_o/R)^{3-D} \tag{2}$$

where δ_o is the mean density and R_o radius of individual grains, D is the fractal dimensions of the cluster. Atmospheric density at the point of maximum light or ionization is

$$\rho_m \sim (\delta\, R)^m (\cos z)^n\, V^l. \tag{3}$$

Substituting $\delta(R)$ from Eq. (2) into Eq. (3) for $d = 2$ we obtain

$$\rho_m \sim (\delta_o\, R_o)^m (\cos z)^n\, V^l. \tag{4}$$

Note that ρ_m is independent of meteoroid size and it density. Empirical values R_o and R_c has been determined by the Eq. (1). We have obtained $R_o = 31\ \mu$, $\log R_c = 0.64 - 1.09 \log V$, where R_c is cm and V in km/s.

According to Eq. (2) in the range of size $2R_o < 2R < 2R_c$ densities of meteoroids decreases with increasing of its radii. As the mechanical strength of meteoroids decrease also so they should be fragmented completely before the beginning ablation of grains. For these type of ablation the Eq.(1) also is valid. The mean size of grains are 30 μ. This value is several times lower than one adopted by Bel'kovich and Tokhtas'ev (1974).

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Infrared J H K Imaging of Comet P/Schaumasse (1992x) During the Pre and Post-Perihelion Phases

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Images of comet P/Schaumasse (1992x) in the J, H and K bands were obtained during the middle of February and March 1993 with the new infrared imaging camera (ARNICA) at the Italian TIRGO telescope. The field of view was about 4 arcmin with a pixel size of 1 arcsec. Since the emission in these IR bands is due to solar radiation scattered by the dust, these images are particular useful for the study of dust component of the inner coma. The data have been analyzed in order to determine the possible presence of fans and jets. The IR color index has been also measured in selected regions with different nucleocentric distances and position angles to check the possible change of the dust composition in the coma.

Search for the Near Infrared Intercombination Lines of Carbon in Comet P/Swift-Tuttle (1992t)

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We have previously discussed the question of the formation of carbon atoms in the metastable level ^1D in a cometary coma produced by photodissociation of CO (Tozzi, Feldman and Festou - 1992, BAAS, **24**, 1019), and have proposed that a measurement of the prompt CI (^1D–^3P) emission at 9823.4 and 9849.5 Å would provide a way to measure Q(CO) from the ground. We have attempted such a measurement on comet P/Swift-Tuttle (1992t) which was observed on 12th and 14th of November 1992 in the near-IR, at Loiano Obs. (BO, Italy). The spatial and spectral resolutions were about 3 arcsec and 5 Å respectively and the slit length projected on the sky was 4 arcmin. Near simultaneous observations with IUE were made to determine the brightness of the CI (^1D–^1P) transition at 1931 Å and of the carbon resonance multiplets at 1657 and 1561 Å. The CN (1-0) and (2-1) bands are clearly visible in the whole 9000–10200 Å spectra. Of the two carbon lines, the weaker one is undetectable over the noise level, while the other one at 9849.5 Å is blended with the OH (3-0) $P_2(2)$ sky line at 9848.48 Å. To identify this CI line it has been then necessary to accurately subtract both the dust scattered solar continuum and night sky lines. Since residual OH (3-0) lines remain on the cometary gas spectra we consider the possibility that they are produced by OH prompt emission.

SOLAR MOTION IN THE GALAXY AND ITS EFFECT ON THE COMET FLUX VIA CHANGING TIDES

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Galactic tides are known to cause a significant and probably dominant perturbing effect on the orbits of Oort Cloud comets. The magnitude of Galactic tides varies during the quasi-harmonic oscillation of the Sun about the Galactic plane as well as with epicyclic motion of the Sun in the Galactic plane. We construct models where these two periods are about 60 Myr and 200 million years. The corresponding variations in the flux of new comets show strong variations in the quasi-periods of 30 million years and 200 million years. The flux of Earth crossers can vary considerably during the shorter cycle and it is further modulated in the longer cycle.

QUALITATIVE AND NUMERICAL-ANALYTIC METHODS FOR INVESTIGATION OF THE EVOLUTION OF ASTEROID ORBITS; M. A. Vashkov'yak.

The present paper contains the short survay of the works,executed by author in 80-th years at the Keldysh Institute of Applied Mathematics,the Russian Academy of Sciences.

The qualitative investigation of the orbit evolution in restricted circular three-body problem [1a,b] is founded on the integrability of twice-averaged scheme or Gauss problem. In these works the analisis of the orbit crossing conditions is carried out,the typical families of the integral curves are constructed for different values of the parameters,the extreme characteristics of the evaluating orbits are calculated. The generalization of the method on the concentric coplanar system of N perturbing bodies has permited to reveal the same qualitative pecularities of the orbit evolution of the asteroids not belonging to the main belt [1c].

More exact numerical-analitic method for investigation of the asteroid orbits evolution [2] was created taking into account eccentricities,inclinations and the secular perturbations of the planet orbits. By use this method,in particular,the posibility of qualitative change of the evolution of perihelion argument for the orbit of asteroid 2335 (JAMES) was discovered [3]. It reduses to the transition from libration regime in circulation one and back over interval of 10^5 - 10^6 years and gives the clear example of the motion in the vicinity of the secular resonance. These results were confirmed qualitatively in [4].

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PHOTOMETRY, POLARIMETRY AND SPIN VECTOR OF 10 HYGIEA

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Asteroid 10 Hygiea has been observed during several oppositions. First estimations of its synodical period gave a value of 18 hours. A paper by Michałowski *et al.* (1991), reported the period of 27.63 hours as well as pole coordinates and triaxial ellipsoid model of this asteroid.

Recently, new photometric and polarymetric observations of Hygiea were carried out at Kharkov Observatory. They allowed us to get new physical parameters for this asteroid.

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ASTEROID 4 VESTA: SIMULTANEOUS UV AND IR SPECTROPHOTOMETRY.

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For eight nights in October and November 1990 a new detailed spectrophotometry in the 360–1050-nm wavelength region of the asteroid 4 Vesta was carried out (in particular the ultraviolet and infrared parts were measured). The observations show that the ultraviolet part of the spectrum and the pyroxene band profile (800–1000 nm) varies with asteroid rotation. The nature of the variation is correlated with small peculiarities of the V-lightcurve.

Dynamics of Cometary Tail Plasma Structures during Comet Motion within the Solar System.

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On the basis of preceding study [1], we believes that the large-scale ray structure of cometary plasma tails is resulted from the filamentation instability development due to the solar wind flow penetrating into the cometary plasma. Visual change in above structure during comet motion around the Sun is the theme of our consideration. Time scales of the variations of plasma parameters are assumed to be sufficiently larger than instability development time.

Cometary rays appear at the distances of r=9 a.u. from the Sun as were observed for Humason (1959 X) comet [2]. A minimum distance from the Sun where the rays are distinguished may be thought of as 0.6 a.u. for Halley (1910 II) [3] and even as 0.46 a.u. for Kohoutek (1973 XII) [4] comets.

Cometary plasma density and that of solar wind may have a profound effect on the maximum ray size l_{max} [1]. Inasmuch as cometary plasma ion density dependence on r may be considered as $n_{i2}=n_{0i2}\cdot r^{-3.3}$ [5] and that of solar wind protons as $n_{i1}=n_{0i1}\cdot r^{-2}$, where n_{0i1} and n_{0i2} are the proper densities at r=1a.u., l_{max} depends on r approximately as $r^{0.65}$. By virtue of the fact that the condition $\omega_{pi2}\gg\omega_{pi1}$ is one of the assumptions of the theory the maximum ray size is expected to be $2\cdot l_{max}$(r=1a.u.) at r=2.5 a.u. The low limit of this value is reached at r=0.46 and is estimated as $2l_{max}$(r=1a.u.)/3. The above values are not too different from the mean value [1]. At greater distances where $\omega_{pi1}\gg\omega_{pi2}$ cometary rays disappear gradually.

Generation of helical forms in cometary plasma tails is also discussed.

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ANALYSIS OF THE PLASMA-COMA OF COMET P/HALLEY WITH IMAGE-PROCESSING OF DATA FROM BOCHUM'S ARCHIVE.

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34 glass plates (32 with CO^+ filter and 2 with $N_2{}^+$ filter) with a field of view of 28°.6 X 28°.6 and a resolution of approximately 30"were digitized with a PDS 2020 microdensitometer (1 pixel = 25 μm X 25 μm = 47"X 47"), analysed in relative intensities, or when possible in absolute intensities.
The CO^+ filter glass plates were taken from 1986 March 29, to April 17 with an exposure time between 20 and 120 minutes. With the help of Stellingwerf-Theta-Minimum-Method, a period of 2.14 days results from the analysis of the structures in the plasma-coma obtained by subtracting subsequent images.

Cometary material Analysis: Chances for Small Missions

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Abstract

Space Missions VEGA 1+2 and GIOTTO to comet p/Halley provided the only mass-spectrometric data on cometary organics available so far. The analysis of the minor constituents on the mass spectra by Kissel and Krueger (1987) allowed a characterization of the nature of the organic material as mostly unsaturated hydrocarbons with a low fraction containing Oxygen or Nitrogen as heteroatoms. On this basis Krueger and Kissel (1989) developed a scenario for a possible role of comets in the origin of life on earth. Later a comparison with the PICCA data from on board GIOTTO allowed to estimate the average molecular weight of the refractory part of the organics to be some 150 to 250 Da.

Within NASA the DISCOVERY program for small mission has currently selected three cometary mission proposals for further study: One CONTOUR providing a flyby at three different comets, carrying a camera and a dust mass spectrometer, C^4 MISSION (Cometary Coma Chemical Composition) carrying a camera, and a gas chromatograph to a comet rendezvous, and SMACS even smaller crafts to asteroids and comets carrying a camera and maybe one additional instrument. New design of a dust impact mass spectrometer demonstrates the versatility of such instruments and the value small missions can have for cometary research.

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Spectra of comet Swift-Tuttle 1992t obtained with the twin spectrograph at the 3.5m telescope of Calar Alto observatory

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The twin spectrograph of Calar Alto Observatory consists of two spectrographs (arms) which are fed from a single slit via a colour divider. This allows two spectra (one in the red arm, the other in the blue arm) to be recorded simultaneously, so that emissions widely separated in wavelength can be compared.

In the evening of November 18, 1992, four twin spectra of comet Swift-Tuttle 1992t were obtained with this instrument at the Calar Alto 3.5m telescope. In the blue arm an RCA CCD with 1024×640 pixels of $15 \mu m$ square size and in the red arm a GEC CCD with 1152×770 pixels of $22.5 \mu m$ square size was used. The dispersion was 1.6 Å per pixel in the blue arm and 1.1 Å per pixel in the red arm, respectively. The first two twin spectra cover in the blue arm the range 3000-4720 Å and in the red arm the range 6000-7250 Å. The remaining two twin spectra cover in the blue arm the range 3300-5160 Å and in the red arm the range 7130-8200 Å. The slit length, projected in the sky, is 4 arcmin. The slit was oriented along the solar-antisolar direction which at the time of the observations was not far from perpendicular to the horizon to minimize refraction effects. The comet was held at the center of the slit. At the end of the observations the elevation of the comet was 11°. A spectroscopic standard star and the solar type stars 16 Cyg A and B were recorded to allow absolute calibration and subtraction of the dust continuum. Unfortunately, the observing conditions were mostly non-photometric. The spectra show with high signal/noise the neutral emissions of OH, NH, CN, C_3, CH, C_2, [OI], and NH_2. The ion emissions are much fainter. CO_2^+, OH^+, CO^+, N_2^+, and H_2O^+ are present.

The spectra are being processed to extract and compare the emissions of the blue and red CN bands, of OH and [OI], of NH and NH_2, and of all the ions.

A SEARCH FOR SMALL BODIES IN L4 AND L5 OF THE EARTH-SUN SYSTEM

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Abstract

The existence of small bodies near the Lagrangian points of planets other than Jupiter has long been a subject of speculation. The recent discovery of a Trojan in the orbit of Mars tempts one to surmise that similar bodies may exist in Earth's orbit. We have carried out a search for detections of small bodies in the L4 and L5 libration regions of the Earth-Sun system using the IRAS survey data. The sensitivity of IRAS to detect Earth Trojans by their thermal emission exceeds that of previous photographic surveys, while the nearly total sky coverage of IRAS permits a relatively uniform search extending to high ecliptic latitudes.

We have extracted all (~760,000) of the high reliability 12μm point source detections from the IRAS detections file, CN28, that were observed at solar elongations between 60° and 88°. We have modeled the expected distribution of particles trapped in L4 and L5, and bounded their apparent motions in a coordinate system rotating with the Earth about the Sun. Using this model we have searched the detections for sources that define trajectories corresponding to Earth Trojans with osculating orbital elements in the range of semimajor axis $0.994 < a < 1.006$; eccentricity 0.0 to 0.034; and inclination from 0° to 30°. A trajectory is defined by linking three or more detections (with similar infrared colors) that share the same sense of apparent motion.

We also created 1077 orbits of simulated Earth trojans, 500 that passed through the region of L4 scanned by IRAS during the time of the IRAS mission, and 577 that passed through L5. IRAS would have detected 311 of these in L4 and 549 in L5. Half of these were detected on at least 4 occasions in L4, and at least 7 times in L5. The maximum number of detections of a single object was 42. This is due to the high degree of redundancy of the IRAS scan coverage. The simulated trojans were used to tune our linking algorithms, and to provide information relating to the completeness and reliability of the search.

A list of candidate Earth-trojans is presented and their physical properties discussed. A statistical assessment of the survey is made in terms of its coverage of the libration regions, its completeness, and its reliability. These results are further discussed in the context of their implications about the Earth-trojan population.

Activity in Distant Comets by Dust Tail Analysis: A Case of Comet Levy 1990XX

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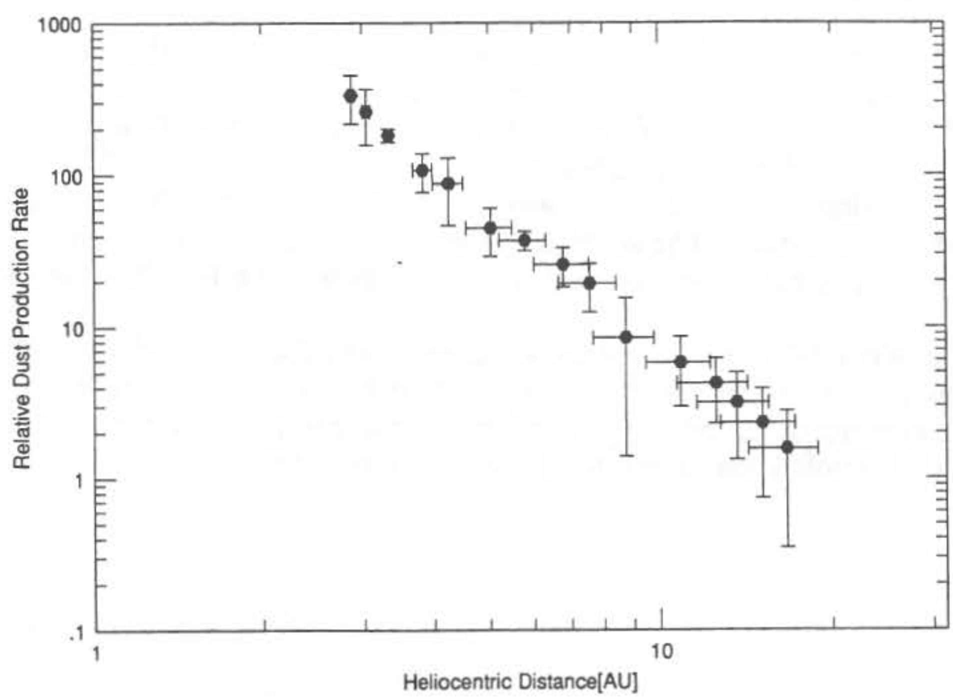
Abstract

Some of new comets show the extended dust tail, which was formed at large heliocentric distance such as 10 A.U. or more. This "old" tail can be used to study the cometary activity in the large heliocentric distance. Moreover, the history of the activity can be explored by the analysis of the intensity distribution of the tail on the basis of some assumptions. We analyzed the dust tail of Comet Levy 1990XX, which was observed on August 20 1990 with 105-cm Schmidt telescope at the Kiso Observatory, and found a gradual increase of dust production rate from 15 A.U. as shown in figure. This result indicates that volatile material such as CO_2 or CO controled the cometary activity of this new comet at the large heliocentric distance.



Relative Production-Rate Variation with Heliocentric Distance derived from the Dust Tail Analysis of Comet Levy 1990XX.

Deriving CO_2 and CO abundances from cometary spectra taken with the Hubble Space Telescope

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Three comets have now been observed spectroscopically with the Hubble Space Telescope (HST): periodic comet P/Hartley 2 (1991 XV) in 1991 September, the dynamically new comet Shoemaker-Levy ($1991a_1$) in 1992 July, and periodic comet P/Schaumasse (1992x) in 1993 March. Several new cometary emissions were clearly detected in the 1800–2300 Å region in comets P/Hartley 2 and Shoemaker-Levy and have been identified with the Cameron system of CO. We have analyzed the Cameron band emission observed in the HST spectra considering five possible excitation mechanisms: photodissociative excitation of CO_2, electron impact dissociative excitation of CO_2, dissociative recombination of CO_2^+ with electrons, electron impact excitation of CO, and resonance fluorescence of CO in the Cameron system. In the case of P/Hartley 2, we find that photodissociative excitation of CO_2 is probably responsible for at least 60% of the emission, which means that these observations of the Cameron bands can be used to derive the relative CO_2 abundance in the nucleus. For P/Hartley 2 we obtain $CO_2/H_2O \sim 4-9\%$, with the highest value being valid if photodissociative excitation is responsible for *all* of the emission and the lowest value (which we regard as much less likely) being valid when the contributions from the other excitation processes are pushed to rather extreme upper limits. Similar conclusions apparently apply to the case of comet Shoemaker-Levy. We have searched for CO in these comets by looking for emission in the Fourth Positive Group bands near 1500 Å. In P/Hartley 2 we find that $CO/H_2O \leq 2\%$ (3σ), while there is a tentative detection of CO in Shoemaker-Levy at a relative abundance of a few percent. Emissions in the (B–X) and (A–X) bands of CO_2^+ were detected in comets P/Hartley 2 and Shoemaker-Levy. In principle, these bands can also be used to probe the CO_2 abundance, but our observations demonstrate that the excitation mechanisms for these bands are poorly understood.

[1] On leave from the *Space Telescope Science Institute*

Galileo NIMS Thermal Observations of Asteroid 951 Gaspra

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The Near Infrared Mapping Spectrometer (NIMS) onboard the Galileo spacecraft performed spectral and thermal imaging of asteroid 951 Gaspra during the spacecraft flyby on October 29, 1991. Analysis of the spatially resolved thermal images give peak brightness temperatures of 225 to 235 K, depending on the emissivity assumed. Estimated color temperatures from a 3-wavelength (4.43, 4.71, and 4.99 µm) least-squares fit are similar. These results have been compared with a thermal model of asteroid 951 Gaspra at the time of the 1991 Galileo encounter, constructed using the KRC program (Kieffer et al., J. Geophys. Res. **82**, 4249, 1977). The observed peak temperatures suggest that the thermal behavior of the surface of Gaspra can not be simulated with either a "bare rock" or "deep regolith" model. The implied thermal inertia is ~0.0025 cal cm^{-2} $sec^{-1/2}$ K^{-1}, somewhat more than twice the value typical for the Moon. These results suggest the existence of a modest regolith on Gaspra, which could be a thin dust layer, a combination of dusty patches and rock outcrops, or a rubble pile mixture of fine and coarse material. Additional NIMS measurements of the hemispherically averaged temperature on Gaspra as the spacecraft approached the asteroid will also be reported. Differences resulting from other choices for thermo-physical parameters in the model will be explored. Similar measurements are currently being planned for the Galileo encounter with asteroid 243 Ida, which will occur in late August of 1993. This work was supported by NASA through the Galileo Project at JPL.

GROWTH OF PLANETESIMALS IN THE ASTEROID BELT. G.W. Wetherill, Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015 USA

Calculations of runaway growth of ~ 10^{18}g planetesimals at 1 AU (1) have been extended (2) to include:

1. 3-body effects in the low velocity regime (3,4).
2. Independent variation of *e* and *i* (5).
3. Fragmentation (both catastrophic and cratering).
4. Formation of neighboring runaway bodies.

Runaway is initiated by a brief excursion of larger bodies into the low velocity regime after ~ 10^4 years, leading to rapid merger of these bodies because of their low inclinations and large gravitational cross-sections. Formation of ~ 10^{25}g runaway bodies then increases the velocities between these bodies and the smaller planetesimals, tending to slow runaway growth. This is offset by the self-regulating effect of fragmentation of the smaller bodies. Collision fragments are slowed by gas drag, facilitating their capture by runaway bodies. Runaway growth thus occurs at a nearly uniform rate, leading to ~ 10^{26}g bodies in ~ 10^5 years at 1 AU.

These calculations have been extended to the asteroid belt (2.5 AU). This introduces differences as a result of the $a^{3/2}$ dependence of the orbital period, differences in the low velocity "gravitational range" of the bodies, and differences in the boundary of the low velocity regime for a given relative velocity. For the same surface density, Ceres-size bodies are formed after ~ 80000 years, and continue their growth to form ~ 10^{26}g bodies after ~ 1.7×10^5 years. Growth rate is approximately proportional to surface density.

Formation of "asteroid size" final bodies, rather than objects the size of small planets, depends on whether or not external perturbations, presumably by Jupiter, can quench the runaway at ~ 10^5 years. If so, the evolution of the asteroid belt can proceed collisionally in the way described earlier (6). If not, an alternative model (7) in which large runaways, together with Jupiter perturbations, gravitationally clear the asteroid belt on a ~ 2×10^8 year time scale, will be more appropriate. Distinction between these models will require better understanding of Jupiter formation, and of evidence relevant to collisional vs. gravitational clearing of the asteroid belt.

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THE DILEMMA OF THE NEW-COMET FLUX

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Abstract: The question of the constancy of the flux rate of "new" comets from the Oort cloud is critical in studies of the origin of comets. The large numbers may be explained by our being in a "comet shower" or else by a loss of intrinsic brightness by new comets during their first passage through the inner solar system—hence the dilemma. Improvements in the quality and quantity of reliable orbits now make possible fairly precise evaluation of the data involved in the dilemma and a realistic comparison of the two alternatives.

If we are in a comet shower the increase with respect to the last several tens of thousands of years is not more than a factor of 1.8 nor magnitude loss of more than $0^m.85$. This applies if new comets are defined as those with periods greater than 10^6 years. If the limit is set at 2.8×10^6 years, we may not be really in a comet shower and a good fraction of the comets with periods in the range $10^6 < P < 2.8 \times 10^6$ yr. may be returning comets. The Oort cloud would then be fairly stable to nearly 40,000 AU.

Comet Giacobini-Zinner & the Draconid Meteor Shower

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Abstract

The most spectacular meteor showers in the present century were probably the Draconid showers of 1933 and 1946. The Draconids gave lesser showers in 1926, 1952 and 1985 but very weak showers or none in other years. It is well known that this is because the meteoroid stream is young and the showers occurred when the parent comet (Giacobini-Zinner ~ period 6.5 years) was close to the Earth. An interesting question is why the showers only occurred in some of the years, and the strongest showers (or storms) only in 1933 and 1946, and not with every return of Comet Giacobini-Zinner to the Earth.

It is our purpose to investigate the dynamical behaviour of the Draconid meteoroid stream and the meteor shower. We discuss the emission mechanism of the particles from the parent body and assume that two sizes of the particles were ejected from the cometary nucleus at the perihelion passage. 500 particles of each kind were ejected at each return and their equations of motion integrated to 1985. The cross-section of the stream in the ecliptic and the profile of the stream are analyzed. We find that both the ejection mechanism and planetary gravitation interact to cause the observed showers but the ejection mechanism plays a more important role. The grains contribute almost nothing to the shower if emitted more than three returns ago and the strongest shower arise from the very fresh meteoroids no more than one year old.

Molecular Rotational Emission Lines Observed in Comet P/Swift-Tuttle

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The 12m telescope of the NRAO on Kitt Peak, Arizona, observed comet P/Swift-Tuttle during two periods in December 1992, before and after its 12 Dec 1992 perihelion. The facility NRAO receivers, using SIS mixers, were used in the two 3mm bands (65-90 GHz and 90-115 GHz) and in the 1mm band (200-270 GHz). Single sideband system temperatures on the sky were 150 K in the 3mm band, and 500 to 1000 K in the 1.3mm band, the latter during post-storm clearing. The spectrometers consisted of two pairs of banks of filters, two polarizations times 128 channels of 100 kHz resolution and 128 channels of 250 kHz resolution at 3mm. At 1.3mm, two polarizations times 128 channels of 250 kHz resolution and 128 channels of 500 MHz resolution were employed. In addition, the NRAO Hybrid Spectrometer was used at its 37.5 MHz bandwidth at 3mm and 75 MHz at 1.3mm, resulting in resolutions of 48.8281 kHz at 3mm and 97.6562 kHz at 1mm, with 768 channels in each of two polarizations. Orbital elements calculated from 1992 observations by Marsden, communicated to us by Crovisier were used on 2 Dec 1992. On 30-31 Dec 1992, elements from Minor Planet Circular 21235 were used. Emission was detected on all three days of observations from the HCN molecule, while no emission was observed from either HDO or CH_3OH lines at the observed frequencies. The observed molecular transitions are given in Table 1 along with the dates of observation, distance from earth, integrated intensity, and radial offset of the beam center from the comet position as reported in Minor Planet Circulars.

[1] The National Radio Astronomy Observatory is operated by Associated Universities, Inc., under cooperative agreement with the National Science Foundation.

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Molecule	Date	Δ (AU)	$\int T_R^* \delta v$ (K km s^{-1})	P"[a] (")
HCN $J=1\rightarrow0$	92-12-02	1.41	0.112	19"
HCN $J=1\rightarrow0$	92-12-31	1.88	0.036	6"
HCN $J=3\rightarrow2$	92-12-30	1.87	0.439	6"
HDO $1_{10} \rightarrow 1_{11}$	92-12-02	1.41	(0.006)[b]	19"
CH_3OH $2_n \rightarrow 1_n$[c]	92-12-02	1.41	(0.009)[b]	19"
CH_3OH $5_n \rightarrow 4_n$[d]	92-12-30	1.87	(0.024)[b]	6"

[a] Position offset between comet and beam center.

[b] rms per 250 kHz channel.

[c] Group of lines near 96.7 GHz.

[d] Group of lines near 241.77 GHz.

STUDY OF PHOTON SPUTTERING OF H_2O ICES, D_2O ICES, CH_3OH ICES, AND H_2O-CH_3OH CLATHRATES

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Measurements of the total yields of ejected ions and electrons from H_2O ices and D_2O ices have been carried out using the He I 584 Å resonance radiation as the incident photon beam. The ices were prepared at 77 K in an ultrahigh vacuum system. The total yield of the ejected ion species and electrons in D_2O ices was determined to be 8.6×10^{-5} and 4.8×10^{-4}, respectively. The results agree very well with those of H_2O ices[1] suggesting that the isotopic effects do not play any significant role in the ion desorption processes of water ices at 584 Å. We are currently obtaining similar data on CH_3OH ices, H_2O-CH_3OH clathrates, and D_2O-CH_3OH clathrates. The detailed results and the experimental setup will be discussed. The data obtained will be useful in understanding the atmospheres of comets, asteroids, icy planets, satellites and rings, and interstellar dust grains.

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Evidence for Rotational Cooling of Water Molecules
Monte Carlo Simulation of Cometary Atmosphere

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The model of an isotropic cometary atmosphere, made up of H_2O and its daughter radicals (H, OH, O and H_2) has been successfully run on the sunstation. The model was checked against the cases of purely adiabatic expansion and vectorial model of OH and was shown to be consistent with the results from numerical techniques for each case. The simulated velocity profile is in good agreement with Giotto measurement of Comet Halley in March, 1986 (Fig. 1). Since the semi-classical cross-section model gives a more realistic description of collisional process than the hardsphere model, therefore rotation cooling of water molecules is needed to fit the measured outflow velocity.

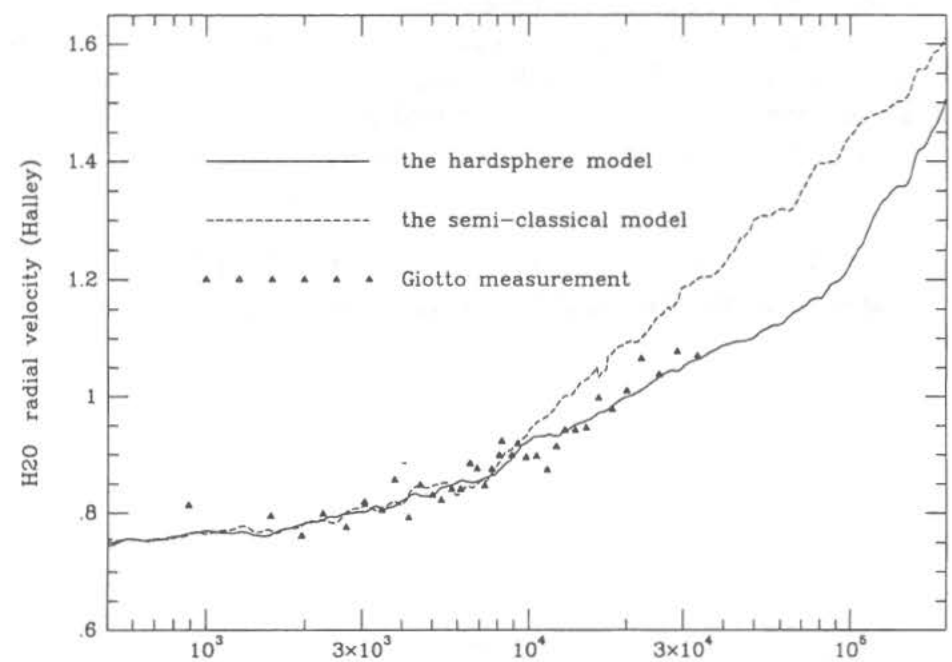

Fig 1 The outflow velocity of H_2O as a function of radius (km)

Models of the Zodiacal Cloud and the Solar System Dust Bands for a Spectrum of Wavebands

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The zodiacal emission (ZE) observed by the Infrared Astronomical Satellite (IRAS; Hauser et al., 1984) holds vital clues to the origin and physical properties of interplanetary dust. The high resolution zodiacal history file prepared by the Infrared Processing and Analysis Center at Caltech has been used to derive a complete structure of the smooth, large-scale zodiacal background and the narrower solar system dust bands in wavebands of 12, 25 and 60μm. In 1984, Dermott et al. (*Nature*, **312**, 505–509) suggested that the solar system dust bands discovered by IRAS are produced by the gradual comminution of the asteroids in the major Hirayama asteroid families. We have developed a three-dimensional numerical model, SIMUL, to simulate the interplanetary dust cloud and to confirm the asteroidal origin hypothesis. The SIMUL model allows for the calculation of thermal flux produced by any particular distribution of dust particle orbits and reproduces the exact viewing geometry of the IRAS telescope. SIMUL takes into account the orbital evolution due to PR drag, light pressure and planetary perturbations, the size-frequency distribution due to collision, the thermal properties of dust particles and their variation with size. SIMUL establishes first a spatial density distribution for the cross-sectional area of the particles, then performs line-of-sight integration to obtain thermal brightness at any direction and any observing time. The simulation results by SIMUL in different wavelengths are compared with corresponding IRAS measurements. The model reveals that (1) the individual families are responsible for the individual peaks in the fine structure of observed thermal brightness; (2) the combinational contribution from major asteroid families accounts for the overall shape of the thermal brightness distribution; (3) the deviation of the symmetry plane of the dust bands from the ecliptic is due to gravitational perturbations. The modeling supports strongly the asteroidal origin hypothesis for the solar system dust bands. However, the overall shape of the background emission can not be fully simulated by asteroidal sources alone.

Crystallinity of the Ice of a Cometary Nucleus

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Abstract

Crystallinity of the ice of a cometary nucleus serves as one of the physical clues to revealing the formation conditions of cometary matter and the history thereafter. Yamamoto (1991) pointed out that whether cometary ice is a condensate in the primordial solar nebula or in the interstellar cloud can be determined by revealing whether ice in the nucleus is crystal or amorphous. In this paper we study conditions for condensation of amorphous ice on a cold substrate and its preservation both theoretically and experimentally.

Conditions for formation and preservation of amorphous ice are presented. It is shown that the formation conditions depend not only on the temperature but also on the flux of water vapor onto the substrate at the condensation. A critical flux F_c above which amorphous ice is formed is given by $F_c = D_s/a^4$, where D_s is the surface diffusion coefficient of water molecules on the substrate and a is the lattice constant of crystalline ice. The time scale t_c for crystallization of amorphous ice is investigated on the basis of the theories of crystalline nucleation and growth. A theoretical expression of t_c is obtained, which has the same form as the empirical formula of $t_c = A\exp(E/T)$ (*e.g.* Schmitt et al., 1989) used in the study of the thermal evolution of comets, where A and E are the parameters, which have so far been determined from experiments.

We made measurement of F_c of water vapor on a substrate of polycrystalline cubic ice in the following way. Water vapor was deposited on the substrate at a constant flux with gradually lowering the substrate temperature. During deposition the structural change of the ice film was observed by reflection electron diffraction. At a temperature T the structure was observed to change from cubic ice to amorphous ice. Thus the critical flux F_c at temperature T was determined. By changing the flux and making the same observations, we obtained F_c as a function of T. It is found that the measured F_c is consistent with the theoretical prediction.

Crystallinity of ice formed in various astrophysical environments is investigated. It is shown that the ice condensed in the primordial solar nebula conditions should be crystalline, whereas that condensed in the interstellar cloud conditions should be amorphous. Implications of the results for the origin of cometary ice are discussed.

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IAU Symposium 160: Asteroids, Comets, Meteors 1993 Conference Abstract

CHEMICAL ANALYSIS OF NATURAL PARTICULATE IMPACT RESIDUES ON THE LONG DURATION EXPOSURE FACILITY

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In situ collection of cosmic dust and space debris on the Low Earth Orbit has yielded new perspective of the near Earth dust environment. In 1990, NASA's Long Duration Exposure Facility (LDEF) was retrieved back after 5.78-year exposure at the mean altitude of 458 km. The Micro Abrasion Package (MAP) experiment (AO023) was returned to the University of Kent at Canterbury (UKC) with aluminium clamps and teflon coated thermal blankets.

The MAP segments located on leading, trailing, north, south and space-pointing faces of the satellite and each section consisted of double layers of either aluminium or brass micron thin foils. Top layers received hypervelocity impacts of natural particles and orbital debris, ratio of which varied at each face, while second foils preserved smaller microcraters and ejecta from projectiles. Dynamics modelling favoured the space pointing face for natural particles and its chemical evidence was discovered in one of the capture cell (Yano et al., 1993). Flux studies established mean impact velocities and densities of such natural particles (McDonnell et al., 1993). For another LDEF experiment (AO187-1), chemical analysis of residues in impact craters at gold plates on the trailing edge has been studied in depth (Hörz and Bernhard, 1992). Recently "catch-up" artificial debris on the west face was reported and contribution of meteor streams toward the north-south asymmetry in flux has been investigated. Thus this paper presents chemical analysis of residues from all available samples of LDEF at UKC in order to determine directionality and origins of each impact and to understand those phenomena.

The MAP segments on key faces of LDEF are scanned with an automated stereo CCD camera system and Scanning Electron Microscope to identify individual impacts. Energy Dispersive X-ray Spectrum Analyser examines elemental composition of residues on the second layers and the exit side of the first layers. Due to its double layer capture cell structure, chemical analysis not only derives materials but also reveals connections between first-layer perforations and second-layer residues. Aluminium clamps are also searched for residues inside craters. Ejecta streams on teflon thermal blanket are tested for their composition. Pre- and post-flight contaminations and secondary impacts effects are excluded.

Some silicate micrometeoroids as well as mafics were traced but no definite man-made objects were discovered on the space pointing face. Indication of natural particles was also discovered on the south clamps while the west face was studied and compared with the AO187-1 studies.

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Nongravitational Effects on Comets

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The cometary nongravitational accelerations arise when vaporizing ices impart a rocket-like thrust to the cometary nucleus. Although there have been several attempts to account for these nongravitational effects, the model introduced by Marsden, Sekanina, and Yeomans in 1973 is still the most widely used. Using observational data and this latter model, one solves for parameters in each of three orthogonal components that represent the thrust acceleration components, in $AU/(day)^2$, when the comet is one AU from the sun. In general, only the radial (A1) and transverse (A2) components in the comet's orbit plane are included in the orbit determination because a solution for the component (A3) normal to the comet's orbit plane rarely produces a meaningful result. Implicit in this model are the assumptions that the cometary outgassing is due to vaporizing water ice but the model does not include assumptions concerning the thermal lag angle (the angle between the subsolar point and the region where the outgassing reaches a maximum) nor are there any assumptions on the size or location of the active region(s). During each return to the sun's neighborhood, the model computes the average radial and transverse thrust accelerations which are assumed to act symmetrically with respect to perihelion. In the pre-Halley era, the magnitude, sign, and time variation of these computed nongravitational parameters were often interpreted in terms of the nucleus' rotation direction, its thermal lag angle, and the precession of the rotation axis with time. In these simpler times, the observed acceleration (deceleration) of a comet's mean motion would be explained in terms of an outgassing nucleus with a small thermal lag angle in retrograde (direct) rotation; the radial nongravitational parameter (A1) would be positive and larger in magnitude than the corresponding transverse parameter (A2). Prompted by the discrete active areas evident in the spacecraft images of comet Halley's nucleus, this simple and straight forward physical interpretation of nongravitational effects is giving way to the more complex realities of nature. Whatever its limitations, the existing model for nongravitational effects **has** substantially improved the orbital solutions and ephemerides for most active comets and nongravitational parameters already exist for a large number of comets. One must ask how these parameters can be correctly interpreted to extract useful information on the physical characteristics of cometary nuclei.

Through the recent work of M. Festou, H. Rickman, L. Kamél, D. Yeomans, P. Chodas and others, it has become apparent that much of the observed nongravitational effects are due to a radial nongravitational acceleration acting asymmetrically with respect to perihelion rather than being due to the transverse component acting symmetrically. Largely as a result of a continuing series of papers by Z. Sekanina, the critical role of small localized active areas is being defined. The location of these active areas on the cometary nucleus and the orientation of the nucleus rotation axis determine where in a comet's orbit a particular source will be exposed to sunlight and become active. The acceleration or deceleration of a comet's mean motion can then be understood in terms of when a particular source (or sources) becomes active. In this new physical model, thermal lag angles are not necessary, the rotation direction is not necessarily related to the determined nongravitational parameters, and the sign of the radial parameter (A1) can be positive or negative. The normal nongravitational parameter (A3) is only meaningful in very specialized circumstances and discontinuous values for the parameters over time can result when old sources cease or new sources become active.

Analysis of 4 Disconnection Events (DEs) in Halley's Comet

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Study of DEs for the purpose of determining the physical processes responsible involves the kinematics and solar-wind conditions for each event. We present the circumstances for 4 DEs in Halley's Comet listed by the kinematic time of disconnection:

(1) Dec. 13.5, 1985. The sector boundary was detected by PVO, Vega-1, and shown by geomagnetic indices. Additional solar-wind data is sparse;

(2) Dec 31.2, 1985. The sector boundary was detected by IMP-8, PVO, ICE, and Vega-1. The solar wind conditions measured by IMP-8 are as follows. At the sector boundary, the density was around $10/cm^3$, the solar wind speed was about 400 km/sec, which was decreasing slowly from 700 km/sec three days earlier.

(3) Feb 21.7, 1986. This is a DE with but a single known image. The time of disconnection is determined by assuming average kinematics. The sector boundary was detected by IMP-8, ICE, and Vega-1. The solar wind conditions come from IMP-8; the density was $7/cm^3$, and the speed 550 km/sec.

(4) Feb 28.7, 1986. The sector boundary was detected by the geomagnetic indices and PVO. The plasma data from PVO shows that the density was $35\text{-}70/cm^3$ (corresponding to $17\text{-}34/cm^3$ at 1 AU) and the speed was 340 km/sec.

These DEs show various degrees of correlation with different physical models, and for some the in situ data is sparse. However, consideration of all obvious DEs in Halley's Comet, 1985-1986, greatly reduces the impact of uncertainties in single events. These DEs are included in the investigation by Brandt, Caputo, Niedner, and Yi (This Meeting) which concludes that DEs are strongly associated with sector boundaries and not with high-speed streams.

Properties of Near-miss among Asteroids

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We calculated the orbital motion of about 4,500 numbered asteroids taking into account the effect of the gravitational attraction among asteroids as well as the perturbation of nine planets. The calculation is carried out for about 130 years in the future, and such close encounters that distance between two asteroids is less than 0.01 AU are obtained for this period.

About 12,000 near-misses are obtained by this calculation, and, as expected, most of them occur in the main belt and near the ecliptic plain. However, this calculation reveals that near-misses among asteroids take place in rather large region of the solar system. The range where near-misses take place is $0.99 < r(\mathrm{AU}) < 4.89$ and $-1.12 < z(\mathrm{AU}) < 1.15$, where r is heliocentric distance and z is distance from the ecliptic plain. The near-misses in the inner region of solar system occur among Apollo-Amor type asteroids, and the outermost near-miss occurs between two asteroids in Hilda group. Near-misses among Koronis, Eos, and Themis families are also obtained. One of the interesting results is that, at the inner edge of the main belt, the number of near-miss decreases steeply, although, at the outer edge, it decreases gradually, and relatively large number of near-misses occur outside of the main belt ($r > 3.2$). This result suggests that collision of asteroids is possible even in the outside of the main belt.

In addition, we analyzed the dependence of near-miss on orbital elements (a: semimajor axis, e: eccentricity, i: inclination) and mass of asteroids, and we obtained following results: (1) The number of near-miss decreases as a becomes large. This may be caused by the effect of period of orbital evolution. (2) The near-miss rate does not depend on the value of e. (3) The near-miss rate becomes small as i becomes large. This is because the number density of asteroids becomes smaller if z becomes larger. (4) It seems that small asteroids are much likely to make near-miss. This is probably due to the fact that small asteroids observed now have a tendency that their a and i are small.

Circular Least Square Approximation for Family-like Groups

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ABSTRACT

A family-like group of asteroids distribute approximately on a circle in the v-u plane and in the q-p plane, where the v-u plane is defined by the polar coordinates with radius e(eccentricity) and angle ϖ(longitude of perihelion), and the q-p plane is defined by the polar coordinates with radius sinI(I=inclination) and angle Ω(longitude of node).

Then a new least square method for circularly distributed data is constructed and is applied to Amor family-like group. By this method, we can obtain the radius r and the rectangular coordinates (a, b) for the center of the circle, which make $d^2 = \Sigma(r - r_j)^2$ to be minimized (r_j denotes the distance of each data from the center of the circle).

A REGULARIZED, UNIVERSAL FORMULATION FOR THE CALCULATION OF EPHEMERIDES OF THE N-BODY PROBLEM. Pedro E. Zadunaisky[1] and Claudia M. Giordano[2], [1]CONAE and Universidad de Buenos Aires, Argentina, [2]Universidad Nacional de La Plata, Argentina.

In a previous paper [1] we showed that the vectorial equation of motion of the perturbed two-body problem

$$\ddot{r} + k^2(M+m)r/r^3 = P$$

where $r(t_0) = r_0$ and $\dot{r}(t_0) = \dot{r}_0$ are initial conditions and P is a small perturbing function, can be solved by a process where the final step has the form

$$r(t) = Fr_0 + G\dot{r}_0 + Hg_0$$
$$\dot{r}(t) = \dot{F}r_0 + \dot{G}\dot{r}_0 + \dot{H}g_0$$

Here $g_0 = r_0 x \dot{r}_0$ is the angular momentum vector orthogonal to the instantaneous plane of motion of the perturbed body and F, G, and H are scalar functions of t and of r, $\dot{r}$, P, and their derivatives at the instant t. If the perturbing function P is either null or coplanar with the instantaneous plan of motion the function H is also null and our formulas reduce to the classical Lagrangian form.

Our process involves a regularizing transformation of t for the case where the perturbing function becomes close to a singularity. It involves also the introduction of the so-called "universal functions" defined by a series of the form

$$C_\kappa(\lambda^2) = \sum_{i=0}^{\infty}(-\lambda^3)^i/(2i+k)!$$

that have a very fast convergence and some interesting properties in this appication [2–4].

In the present paper we extend our method to the N-body problem covering cases where the perturbing forces can be either gravitational and nongravitational—like those acting on comets—or drag forces acting on artificial objects. Also we demonstrate that the method is convergent and numerically stable and that accurate estimations of local and global errors can be obtained. In our numerical experiments we have included the Lagrangian Problem of Three Bodies and the motion of the entire solar system. Our results show the advantages in precision and stability of our approach as compared to some leading methods of numerical integration of ordinary differential equations.

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SIX-CENTIMETER RADAR OBSERVATIONS OF (4179) TOUTATIS. A. L. Zaytsev[1], A. S. Vyshlov[1], O. N. Rzhiga[1], V. A. Shubin[1], A. P. Krivtsov[1], O. S. Zaytseva[1], A. S. Nabatov[1], R. Wielebinski[2], W. J. Altenhoff[2], V. A. Grishmanovsky[3], Yu. F. Kolyuka[4], O. K. Margorin[4], A. G. Sokolsky[5], V. A. Shor[5], [1]Institute of Radio-Electronics, Moscow, Russia, [2]Max-Planck-Institut, für Radioastronomie, Bonn, Germany, [3]Instrument-making Research Institute, Moscow, Russia, [4]Space-Flight Control Center, Kaliningrad, Moscow region, [5]Institute of Theoretical Astronomy, St. Petersburg, Russia.

A radar signal was transmitted from Eupatorian Deep Space Station (Crimea) and after reflection from asteroid was received at Effelsberg (Germany). The 70-m antenna and 50 kW transmitter were used at Eupatoria, 100-m antenna and 90 K noise temperature receiver at Effelsberg. When transmitting, the predicted Doppler shift was compensated . Continuous wave or frequency-modulated radar signals were used.

The observations were carried out on 8 and 9 December 1992. Spectrum analysis of echo signals was made with 0.02-Hz frequency resolution. An echo bandwidth B, which depends on synodic rotation period and aspect angle, was estimated by three different methods. The values of B are 1.8–2.2 Hz. After correction for fast apparent motion, preliminary estimations of proper rotation period of Toutatis give values within interval from 9.9 to 11.7 days (if the rotation axis was orthogonal to the line of sight and taking the asteroid diameter to be equal to 6.0 km).

Two orthogonal circular polarizations have been received simultaneously. Polarization ratios are equal to 0.24–0.28. This fact gives evidence of high degree roughness of the asteroid surface at the wavelength scale. The most interesting result is a bimodal distribution of power spectra for both polarizations. The depth of a gap is as much as Pmax/2. It testifies that (4179) Toutatis is a double object, like asteroid (4769) Castalia. The preliminary estimation of radar cross section for 9 December gives the value 0.26 km^2. The time delay and frequency shift data were obtained with the precision that permits their use for more precise determination of the Toutatis orbit.

ORBITS OF SHORT PERIOD COMETS CAPTURED FROM THE OORT CLOUD

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Oort Cloud comets occasionally obtain orbits which take them through the planetary region. Then perturbations by the planets are likely to change the orbit of the comet to the extent that it is either lost into interstellar space or it becomes a short period comet. We model this process by using a Monte Carlo method and cross sections for orbital changes, i.e. changes in energy, inclination and perihelion, in a single planet – comet encounter. The influence of all planets is considered. We study the distributions of orbital parameters of observable comets, i.e. those which have their perihelia smaller than a given value. Both Jupiter family and Halley group comets can be identified with reasonable distributions of orbital elements.

The Effect of Collision in the Asteroid Belt

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Abstract

The collision of asteroids plays an important role in the origin and evolution of the asteroid belt. In order to assess quantitatively the effect of asteroid collision, we considered a Hill' s problem consisted of the Sun, Jupiter and asteroids in the asteroid belt. For the asteroid motion, in addition to the gravities of the Sun and Jupiter, the gravitational interaction among asteroids in the belt has to be taken into account. It can be calculated by use of the annual mesh difference algorithm. The initial orbits of asteroids in the asteroid belt are chosen at random, their orbital elements are obtained by the numerical integral method.

Assuming that the asteroid collision is inelestic with the restitution coefficient $q(0<q<1)$, we calculated the collisional probability and impact velocity in the asteroid belt. The evolutional processes of asteroid belt are presented for different initial conditions and various collision parameters. The results show that the orbital elements and average energies of asteroids are changed with the initial distribution and parameters. Finally, the dynamical properties of the asteroid belt are discussed for the several cases.

A STUDY ON THE HISTORICAL RECORDS OF LEO SHOWER IN CHINA

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ABSTRACT: 39 new historical records about Leo Shower have been identified from Defang Zhi (city chronicles) and other ancient books of China. It is an important supplement to the relevant records as known before. At present time, the amount of the published records of Leo Shower increases to 70. Especially among them, 21 records from different cities gave much information during the appearance of Leo Shower in 1533. The main conclusions, obtained on the basis of the study on these old and new data, are as follows:

(a) The conventional positions of apparent luminous points were located near to the southern part of UMa, about 20 Deg. -- 30 Deg. away from the radiant.
(b) It seems to the meteroids escaped from mother body-Temple comet through collapse,instead of explosion. Then, the collapse process continued in smaller scale when they moved around the sun.
(c) The distribution of meteoroids along its orbit is very non-uniform. Leonids may be consisted of two large pieces of 'meteoric clouds', which have different sizes and densities. The distance between these two clouds was 28,000,000 km.
(d) The earth has only moved across the leading cloud before 1533 and across the following cloud after 1533, but across both clouds one by one in 1533. It is probably the reason why Leo Shower has subsisted rather longer time in that year.
(e) The dispersing speed of the meteoric cloud over the orbit was about 0.7-1m/sec.
(f) The brightness of the sky while Leo Shower appeared in 1533 was around 1 Mag. -- -1 Mag.

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THE ORBIT OF (944) HIDALGO AND THE MASS OF SATURN

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New orbital elements of the minor planet (944) Hidalgo have been determined using 246 astrometric observations (made during 15 oppositions in the period 1920-1992) selected and weighted according to mathematical criteria. A purely gravitational fit to the all observations yields a RMS residual of 1."32. The inclusion of cometlike nongravitational effects in the equations of motion reduces the RMS residual to the value of 1."23 and partly flattens systematic residual trends. It is interesting that the radial and transverse components of the nongravitational acceleration (given by A_1 and A_2 parameters respectively) are rather indeterminate, while the component normal to the orbit plane (given by A_3 parameter) seems to be quite resonable: $A_3 = -(0.15 \pm 0.02) \times 10^{-8}$.

The motion of Hidalgo is clearly influenced by Saturn and therefore can be used to the improvement of the mass of this planet. The value of reciprocal mass of Saturn is determined to be 3497.996 ± 0.057.